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EFFECTS OF FEEDING SEVERAL DIETARY CONCENTRATIONS OF SODIUM TO BABY PIGS

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Introduction

This laboratory has reported the effects of diarrhea on sodium retention by pigs (Reber and Whitehair, 1955; Reber and Yusken, 1956). A level of 2.34% dietary sodium chloride appeared to be beneficial for baby pigs infected with transmissible gastroenteritis. This was considerably higher than the 0.5% level recommended by the National Research Council (Hughes, *et al.*, 1944) for healthy weanling pigs. These findings indicated additional investigations of the effects of feeding rations containing various levels of sodium should be made, and this is a report of such investigations. The data of this study have been combined with data from previous investigations for statistical analysis in an attempt to define the optimal level of sodium to be included in a ration fed to baby pigs.

Materials and Methods

Hampshire pigs were maintained in individual metabolism cages designed for quantitative collection of urine, feces and uneaten feed. The ration was suspended in four parts warm water, by weight, and homogenized in a Waring blendor. If the pig ate all of the feed, its allotment was increased the following day. The amount of feed offered never exceeded that of the previous day by more than 4%. Uneaten feed was collected after each feeding. Collections of urine and feces were made at various intervals ranging from 24 to 96 hours. Urine was collected in bottles which contained sulfuric acid. A portion of the urine was stored in a corked flask until sodium analysis could be performed. All uneaten feed and feces were kept refrigerated at -10° C. until they were prepared for sodium analysis. All collected material was digested with nitric acid or a mixture of nitric and sulfuric acids. Analysis for sodium was by flame photometry using lithium as an internal standard.

The composition of the ration is given in Table 1. The level of sodium in the ration was increased by adding sodium chloride at the expense of lactose and dextrose. In one experiment, rations containing 234, 272, 547 and 647 mgs. of sodium per 100 gms. were fed. Triplicate analyses for sodium were made on ration samples and the averages used to calculate sodium intakes. The diets were fed for periods ranging from 3 to 20 days before collections were made.

In another experiment sodium chloride was added to the basal ration (Table 1) to make rations that contained 300, 500 and 700 mgs. of sodium per 100 gms. The rations as fed were not analyzed for sodium. Three litters of pigs were born within a three-day period. The oldest of these were seven days of age when brought into the laboratory and housed in individual metabolism

TABLE 1.—Rations Used in Sodium Studies on Baby Pigs.[1]

Ingredients	*Weight (gms.)*
Vitamin-free casein	35.0
Lard	40.0
Lactose	10.25
Dextrose	10.25
Salts (U.S.P. XIV)	5.0
Sodium Chloride[2]	—
Vitamin A and D oil (1000 U.S.P. vit. A, 100 U.S.P. Vit. D/gm.)	0.5
Wheat germ oil (2 I.U. vit. E/gm.)	1.0

[1] Vitamins (mgs.) added to 200 gms. of dry ration: thiamine, 1.1; riboflavin, 1.8; nicotinic acid, 10.1; inositol, 26.8; choline, 260; para-amino benzoic acid, 5.0; folic acid, 0.13; biotin, 0.025; pyridoxine, 2.0; calcium pantothenate, 7.1; ascorbic acid, 130; vitamin B_{12}, 0.01; menadione, 0.29.

[2] Added at expense of lactose and dextrose.

cages. The rations were fed as a warm homogenized suspension three times a day. Some of the pigs developed a slight diarrhea which lasted only a few days. The pigs were fed their respective levels of dietary sodium for no less than 15 days before collections were made to determine sodium retentions.

The data obtained in the above two experiments were combined with the data obtained in experiments previously reported and subjected to statistical analysis. Previous reports have been made for levels of 9.4 mgs. (Yusken and Reber, 1957), 178 mgs. (Reber and Whitehair, 1955), and 920 mgs. (Reber and Yusken, 1956) of sodium per 100 gms. of ration.

Results and Discussion

The results from all the experiments are summarized in Table 2. The change in average daily body weight by pigs fed the level of 9.4 mgs. of sodium varied from 122 to 259 gms., and 43 of the 45 sodium balances were negative. Those pigs which gained weight lost an average of 0.46 mgs. of sodium and those which lost weight lost an average of 0.48 mgs. of sodium per gram of body weight per day. The study of Meyer, *et al.* (1950) indicated that weight gains and feed efficiency were decreased in weanling pigs fed 5 mgs. sodium per 100 gms. of ration. No sodium balance study was conducted by Meyer, *et al.* (1950) and the degree of sodium deficiency was assessed by observing weight gain and feed efficiency.

Pigs fed the 178 mgs. sodium level retained 90.9% of their sodium intake. This was the highest percentage of sodium retention in this study. The regression coefficient of retention on intake was the highest obtained for all levels of sodium fed, and was statistically significant. The average initial weight of the pigs was 3445 gms. The average daily gain of 255 gms. was the highest observed in any of the experiments. These pigs were fed five times a day while the pigs in the other experiments were fed three times a day. The high percentage of sodium retained is probably related to the high rate of growth of these pigs. The group retained an average of 1.19 mgs. of sodium per gram of body weight gained. Higher retentions of sodium per gram of gain were observed in pigs fed higher dietary concentrations of sodium. Apparently this level of sodium can supply enough sodium for a healthy baby pig, but not enough to offset electrolytic losses in diarrhea. The protective effect of a high dietary level of sodium has

TABLE 2.—Average Daily Sodium Intake and Retention in Baby Pigs.

Na (mgs.) per 100 gms. ration	No. pigs	No. collections	Age of pigs (days)	Na intake (gms.)	Na retention (gms.)	Regression, retention on intake	Probability[1]	Na (mgs.), retention per gms. increase body wt.
9.4	5	45	41-108	4.9	—24.4	0.854	0.25	....
178	12	34	28-34	333	303	0.926	0.02	1.19
234	2	4	14-34	350	134	0.296	0.4	0.81
272	3	7	14-34	212	100	—0.298	0.5	1.60
300	4	9	19-34	393	147	0.503	0.02	1.75
500	4	7	19-34	636	180	0.129	0.6	2.02
547	4	7	14-34	600	237	0.429	0.2	2.63
647	2	4	14-34	711	109	—0.350	0.03	0.70
700	2	5	19-34	893	283	0.227	0.6	2.45
920	4	13	20-30	776	219	—0.062	0.7	2.43

[1] A probability of 0.05 or less is statistically significant.

been demonstrated by Reber and Yusken (1956), in which 920 mgs. of sodium per 100 gms. of ration counteracted potassium losses in baby pigs infected with transmissible gastroenteritis.

In the experiment in which 234, 272, 547 and 647 mgs. of sodium per 100 gms. of ration were fed, there were no consistent relations between intake and retention or between intake and sodium retained per gram of increase in body weight. None of the pigs in this experiment retained an amount of sodium equal to that retained by pigs fed the ration containing 178 mgs. per 100 gms., even though the intake values were greater.

In the experiment in which 300, 500 and 700 mgs. of sodium per 100 gms. of ration were fed, the pigs had an average daily body weight gain of 84, 89 and 115 gms., respectively. The daily sodium intake and retention increased as the concentration of the sodium in the ration increased.

The pigs fed the 920 mgs. level of sodium gained an average of 90 gms. per day. The urinary losses of sodium for these pigs averaged 545 mgs. per day, considerably higher than the average of 31 mgs. observed in those pigs fed the 178 mgs. level of sodium. The urinary volumes of these two groups of pigs were comparable. The amounts of sodium retained per gram of increase in body weight by pigs fed 700 and 920 mgs. of sodium per 100 gms. of ration were about equal. This degree of sodium retention is interpreted to mean that the pigs fed lower levels of sodium would have retained more sodium if their dietary concentration were greater.

It appears that a high level of sodium (2.34% sodium chloride) did not adversely affect body weight gains. The responses of the animals fed the diet containing 0.45% sodium chloride indicated that this level of sodium adequately met the requirements of the growing, healthy baby pig. However, the high average daily retention (90.9%) of the dietary sodium indicates there was a small margin of safety. Although the data from these experiments are limited, it appears the level of sodium included in a ration fed to baby pigs should be higher than 178 mgs. (0.45% sodium chloride). There appears to be considerable biological variation in these studies. Therefore, additional investigations should be made.

Summary

Forty-two pigs whose ages varied from 19 to 108 days, maintained in individual metabolism cages, were fed a synthetic ration in which the sodium content varied from 9.4 to 920 mgs. of sodium per 100 gms. Uneaten feed, urine, and feces were collected for periods of one to four days and daily sodium retentions were calculated. Pigs fed 9.4 mgs. of sodium per 100 gms. of ration lost an average of 24.4 mgs. of sodium and 14 gms. of body weight per day. Pigs fed levels of sodium varying from 178 to 920 mgs. of sodium per 100 gms. of ration had positive sodium retentions. The analysis of these data points out the extreme variations encountered in attempting a determination of sodium requirement. Regression coefficients for sodium retention on sodium intake were calculated for each concentra-

tion of dietary sodium. Pigs fed 178 mgs. of sodium per 100 gms. of ration retained an average of 90.9% of their sodium intake, and grew more rapidly than pigs fed any other sodium concentration. In general, sodium retained in milligrams per gram of increase in body weight increased with increasing sodium concentration, from 1.19 for pigs fed 178 mgs., to 2.44 for pigs fed rations containing 700 or 900 mgs. per 100 gms. of ration.

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The authors wish to express their appreciation to: Donald Swartz and Delores Hughes, Department of Veterinary Physiology and Pharmacology, University of Illinois, for technical assistance; and to Dr. L. Michaud, Veterinary Research Department, Merck and Company, Inc., Rahway, New Jersey, for B-complex vitamins. This work was supported in part by the Illinois Agricultural Experiment Station as a collaborator under a North Central Regional Agricultural Experiment Station cooperative research project entitled "Death Losses in Young Pigs."

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ANALYSIS OF AN ENVIRONMENT AS SUGGESTED BY SHELLS OF FRESH-WATER MUSSELS DISCARDED BY INDIANS OF ILLINOIS

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Introduction

During the past few decades an ever-increasing amount of knowledge has been accumulated concerning the former distribution of freshwater mussels and, to a certain extent, of terrestrial and aquatic gastropods. Information has been derived primarily from two sources. Gastropods and occasionally sphaerids have been found in various geological formations; usually, unionids have been lacking. For the majority of our collections of past populations of freshwater mussels, we must thank the diet of some of the early American Indians.

Along certain rivers, usually part of the Mississippi River basin, these Indians left large refuse piles that were often composed entirely of mussel shells. These middens offer evidence that, at least with some groups of Indians, the clam constituted a chief item of diet. Knowledge of the existence of the middens is usually supplied by anthropologists.

Reconstruction of the physical aspects of a stream environment, as it formerly existed, through an analysis of the habitat-demands of the mussels which were once removed from it is a relatively new field of endeavor. An example of this procedure is a study made of shells taken from a midden on McGee's Creek (Poole site; Matteson, 1953). A report in which past populations of mussels from streams in southern Illinois are compared with mussels now existing nearby has been recently published by Parmalee (1956); however, no attempt is made to reconstruct the nature of the environment as occupied by the original mussels. Changes in the bed of the Tennessee River have been demonstrated through a study of its former unionid fauna by Morrison (1942).

Acknowledgments

The author is indebted to anthropologists from the University of Illinois for the large collection of shells which are discussed in this paper. Dr. Elaine Bluhm, Mr. William J. Beeson, and Dr. John C. McGregor contributed materially to this study. Their valuable advice, as well as the shells which they provided, made this study possible.

Description of Site

The midden from which these shells were obtained was located several hundred feet from the present west bank of McGee's Creek. The location, known as the Irvin site, is one mile below the midden of the Poole site mentioned previously. It is situated in Pike County, Illinois, and is about one mile north of Chambersburg. The shells were discarded by Indians of the late Middle Wood-

land culture living in a village which existed about 776 A. D. Approximately one thousand years separate the shells of this midden from those of the midden located at the earlier Poole site. Both dates were ascertained by carbon[14] determination through the efforts of Dr. McGregor.

There is little doubt that the collecting areas of both villages overlapped, although separated by a thousand years. The Irvin site is roughly seven miles from the Illinois River by water, or five miles by land; however, the Illinois River and the lower portion of McGee's Creek did not necessarily occupy their present beds in 776 A.D.

The shells are well preserved. They were embedded in a soil composed chiefly of clay, which had been deposited by past floods involving the nearby stream.

Results

An inventory of the collection revealed 37 species of 22 genera. Where only one specimen of a thin-shelled mussel, *Strophitus rugosus*, was found in the earlier Poole collection, shells representing several thin-shelled genera were now present. Not listed in the following chart are six shells of the terrestrial snail, *Anguispira alternata* (Say), 1816. This snail is notorious for securing lime from the shells of other snails, both living and dead. Its affinity for the lime of which the mussel shells were composed doubtlessly explains its presence in the collection.

Discussion

The habitat-demands of various species of mussels may coincide to the extent that they tend to occupy a common aquatic environment. They thus constitute a rather constant community. The number of species which occupy a community will vary according to the nature of the environment. When certain members of such a community are found during a survey, one can predict quite accurately which species may yet be found. The accompanying inventory varies little in composition from that of the Poole site, with the exception that several thin-shelled species (*A. grandis, U. tetralasmus, S. rugosus*) are present in the former while only one is found in the latter. It is probable that the thin-shelled forms once existed in the unionid community from which the valves found at the Poole site were secured by the Indians. There are several possible explanations why they were not found in this collection; the most plausible one is that they were subjected to deterioration for an added 1000 years.

With few exceptions, all of the mussels listed here are found in small rivers. There are a few species present whose habitat-demands are such that they can occupy a river of any size. Usually, the size attained by such forms varies directly with that of the river.

A. costata, L. ventricosa, L. Siliquoidea, E. dilatatus, P. c. coccineum, and *A. carinata* are most frequent in this collection; all are typical of unionid communities occupying small or medium-sized rivers. It will be noted that *A. peruviana* and *A. rariplicata* are numerically next most frequent. Both species are found also in larger deeper rivers.

TABLE 1.—Species of Unionids Found at Irvin Site.

	Number identifiable valves	Number for height only	Number complete valves	Mean, for height only, in mm.	Mean height, in mm. (complete valves)	Mean length, in mm.	Percent total population
Amblema costata Rafinesque, 1820	333	67	25	4.67	4.72	6.87	12.93
Lampsilis ventricosa (Barnes), 1823	297	56	24	6.42	6.67	10.12	11.53
Lampsilis siliquoidea (Barnes), 1823	282	91	38	4.02	4.04	6.81	10.94
Elliptio dilatatus (Rafinesque), 1820	273	71	28	3.85	4.00	8.34	10.60
Pleurobema coccineum (Conrad), 1836	250	43	5	3.57	2.80	3.76	9.70
Actinonaias carinata (Barnes), 1823	217	78	31	5.09	4.91	7.82	8.42
Amblema peruviana (Lamark), 1819	175	70	38	4.88	4.67	6.33	6.79
Amblema plicata (Say), 1817	158	58	34	4.91	4.79	6.49	6.13
Fusconaia flava (Rafinesque), 1820	101	28	9	3.18	3.12	4.05	3.92
Fusconaia undata (Barnes), 1823	99	79	15	3.57	3.59	3.92	3.84
Quadrula pustulosa (Lea), 1831	51	43	23	4.05	4.02	4.37	1.97
Proptera alata (Say), 1817	49	4	1	7.35	7.50	11.16	1.90
Lampsilis anodontoides (Lea), 1831	43	2	2	3.50	3.50	7.05	1.67
Actinonaias ellipsiformes (Conrad), 1836	38	9	3	2.04	2.00	3.40	1.48
Lasmigona costata (Rafinesque), 1820	37	4	2	5.45	4.40	8.40	1.44
Fusconaia ebenus (Lea), 1831	29	4	1	4.73	5.00	5.90	1.13
Lasmigona complanata (Barnes), 1823	27	2	1	8.45	8.80	12.10	1.04
Anodonta grandis Say, 1829	21	.....	.....	.....	.....	.....	.82
Uniomerus tetralasmus (Say), 1830	16	.....	.....	.....	.....	.....	.61
Ligumia recta (Lamark), 1819	14	10	4	4.01	3.65	8.75	.54
Pleurobema pyramidatum (Lea), 1831	11	8	1	4.43	4.60	5.50	.43
Strophitus rugosus (Swainson), 1822	11	.....	.....	.....	.....	.....	.43
Elliptio crassidens (Lamark), 1819	9	3	1	6.03	5.90	9.10	.35

	Number identifiable valves	Number for height only	Number complete valves	Mean, for height only, in mm.	Mean height, in mm. (complete valves)	Mean length, in mm.	Percent total population
Cyclonaias tuberculata (Rafinesque), 1820	5	3	1	5.77	5.80	7.00	.19
Quadrula nodulata Rafinesque, 1820	4	3	3	3.80	3.80	4.37	.16
Tritogonia verrucosa (Rafinesque), 1820	4	2	2	3.95	3.95	5.85	.16
Micromya iris (Lea), 1830	3	.....	.....	.....	.....	.....	.12
Micromya lienosa (Conrad), 1834	3	2	.....	3.20	.....	.....	.12
Plagiola lineolata Rafinesque, 1820	3	3	2	3.83	3.85	5.05	.12
Proptera laevissima (Lea), 1834	3	2	2	7.50	7.50	12.25	.12
Plethobasus cyphyus (Rafinesque), 1820	2	2	1	4.65	4.80	6.90	.08
Quadrula metanevra Rafinesque, 1820	2	2	2	4.60	4.60	5.80	.08
Quadrula quadrula Rafinesque, 1820	2	2	.....	4.20	.....	.....	.08
Alasmidonta marginata Say, 1819	1	.....	.....	.....	.....	.....	.04
Arcidens confragosus (Say), 1830	1	.....	.....	.....	.....	.....	.04
Obliquaria reflexa (Rafinesque), 1820	1	1	.....	3.00	.....	.....	.04
Truncilla truncata Rafinesque, 1820	1	1	1	2.90	2.90	4.50	.04
Totals	2576	753	300				100.00

Experience has shown that both may be collected in the lower portions of small tributaries of large rivers, wherever their young have been dropped by fish hosts. The Indians probably gathered them a considerable distance below their village where the creek had entered the flood plain of the Illinois River and had become broader and deeper.

All of the remaining species of unionids which form more than one per cent of the population, with the exception of two, normally occupy rivers of small to medium size. *F. ebenus* and *F. undata* are also found in larger rivers such as the lower portions of the Kaskaskia and Embarrass rivers, or the Illinois.

An analysis of the habitat-demands of those mussels represented by less than one per cent of the total population is of interest. *A. marginata, C. tuberculata, E. crassidens, L. recta, M. lienosa, Q. metanevra, S. rugosus, T. verrucosa,* and *T.*

truncata are seldom found in large concentrations. All are typical of small rivers which flow rather rapidly over a sand-gravel bottom; usually one or both borders will have a narrow band of silty substratum. *A. grandis* is often found in limited numbers along the borders of such a stream, in indentations where the current is slow and considerable silt has gathered.

A. confragosus, O. reflexa, P. Lineolata, P. cyphyus, P. pyramidatum, and *Q. nodulata* occupy the deeper portions of a stream at a point just previous to its flowing onto the flood plain. All prefer deeper water but still demand a firm, somewhat rocky substratum. *P. laevissima* is found almost entirely in deep silt along the edges of slow-moving, rather large streams; it was without doubt gathered from the stream after it had entered the flood plain. *M. iris* typically inhabits headwaters or small rivers where the substratum is of sand-gravel.

Anomalous situations have arisen in regard to several species in this collection. Only two shells of *Q. quadrula* were found. In modern communities composed of the species identified here, this clam is always present in larger numbers. Similarly *Q. pustulosa* should have constituted at least five percent of the total population. Wherever the author has collected *P. laevissima,* he has invariably found *Leptodea fragilis.* None of the latter were present. *U. tetralasmus* is found either in very slowly moving water over a silty substratum or in small muddy sloughs associated with a stream where the water is usually less than two feet in depth. There seems to be no evidence that this condition existed near the midden.

There should have been more than one specimen of *T. truncata.* However, this species is roughly one inch in length and could have been easily overlooked by the Indians or considered not worth taking for its small food content. The presence of large numbers of *E. dilatatus* suggests that an area of shallow, rapidly flowing water must have been present, because this species is found almost exclusively in such a habitat. Usually *L. complanata* exceeds *L. costata* in number, where they occur together; however, the latter possesses a larger soft part and thus might be more desirable as food.

The collection is quite similar in quality and quantity to one that might be removed from a small river today. The mussels appear to be of normal size for the reconstructed habitat from which they were removed; very few immature shells were observed, which would lead one to believe that the Indians selected only adults. With the exception of *L. fragilis* and possibly *Carunculina parva,* all the mussels of a small-river community are present.

An environment which would support the preceding population would consist of a stream which possesses the following characteristics: 1) 40 to 60 feet in width, with a depth ranging from a few inches to about three feet; 2) a decided current; 3) a diverse substratum including areas of sand, sand-gravel, gravel, and silt; 4) a slightly alkaline pH of about 8.1; and 5) little suspended silt.

It is evident that any general col-

lection of mussel shells from the past, which can be accurately dated, will denote quite thoroughly stream conditions which prevailed when they were alive. By continuing to study collections of these old shells it is hoped that eventually a more lucid picture may be formed of the former appearances of some of the rivers of Illinois. As Illinois is known as a land of rivers this revelation will be of value.

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A RESIDUE TEST FOR BOOLEAN FUNCTIONS

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Introduction

A residue test is a convenient means for determining the essential literals (Quine, 1952) in the transmission function describing the electrical properties of a two-terminal combinational switching circuit (Shannon, 1949), and thus indicates which literals are absolutely necessary in a realization of the switching circuit.

The residue test is based upon a pair of identities of the Boolean algebra related by duality (Birkhoff and MacLane, 1953). These identities are 1 and 1′ below.

The validity of these identities follows immediately by using the method of perfect induction with respect to the variable x_k. Note: "+" (sum) is used instead of "U" (cup), "·" (product) instead of "$\cap$" (cap) and a prime (complement) instead of "$\sim$" (negative).

For the purpose of brevity definitions (2, below) are made.

Hence T_{lk} merely denotes the original T with the particular variable x_k in the l state and similarly T_{ok} denotes the original T with the particular variable x_k in the O state.

With the definitions given by the identities of (2), the identities given by (1) and 1′) become, respectively, 3 and 3′, below.

At this point, we define T_{lk} and T_{ok} to be the residues of T with respect to x_k and x_k', respectively.

In what follows, if no composition law is given, the composition "·" (product) is implied. Example 1.

$$(1)\qquad T(x_n,\cdots,x_{k-1},x_k,x_{k-1},\cdots,x_0) \equiv x_k \cdot T(x_n,\cdots,x_{k+1},1,x_{k-1},\cdots,x_0) + x_k' \cdot T(x_n,\cdots,x_{k-1},0,x_{k-1},\cdots,x_0)$$

$$(1')\qquad T(x_n,\cdots,x_{k-1},x_k,x_{k-1},\cdots,x_0) \equiv [x_k + T(x_n,\cdots,x_{k-1},0,x_{k-1},\cdots,x_0)] \cdot [x_k' + T(x_n,\cdots,x_{k-1},1,x_{k-1},\cdots,x_0)]$$

$$(2)\qquad \begin{aligned} T &\equiv T(x_n,\cdots,x_{k-1},x_k,x_{k-1},\cdots,x_0)\\ T_{lk} &\equiv T(x_n,\cdots,x_{k-1},1,x_{k-1},\cdots,x_0)\\ T_{ok} &\equiv T(x_n,\cdots,x_{k+1},0,x_{k+1},\cdots,x_0) \end{aligned} \qquad k = 0,1,\cdots,n$$

$$(3)\qquad T \equiv x_k \cdot T_{lk} + x_k' \cdot T_{ok} \qquad k = 0,1,\cdots,n$$

$$(3')\qquad T \equiv [x_k + T_{ok}] \cdot [x_k' + T_{lk}]$$

Example 1:

$$\text{Let } T(x_3,x_2,x_1,x_0) \equiv x_3' x_2' x_1 x_0' + x_3 x_2 x_1 x_0 + x_3' x_2 x_1 x_0' + x_3 x_2 x_1' x_0$$

Inspect x_1* for its necessary appearance in T.

$$T \equiv x_1\, T_{11} + x_1'\, T_{01}$$
$$T \equiv x_1\,[x_3'\, x_2'\, x_0' + x_3\, x_2\, x_0 + x_3'\, x_2\, x_0'] + x_1'\,[x_3\, x_2\, x_0]$$
$$T \equiv x_1[x_3'\, x_0' + x_3\, x_2\, x_0] + x_1'\,[x_3\, x_2\, x_0]$$
$$T \equiv x_3\, x_2\, x_0 + x_3'\, x_1\, x_0'$$

This indicates that the literal x'_1 is unnecessary in a representation of T, since it combined with x_1 according to the identity

$$x_j\, x_k + x_j\, x_k' \equiv x_j$$

Given any transmission function T, the results of the residue test obtained by means of applying the identities given by (3) can be summarized. The results of the residue test obtained by means of applying the identities given by (3′) is equivalent and need not be carried out here.

Case 1:
$T \equiv x_k\, T_{1k} + x_k'\, T_{0k} \equiv T_{0k} \equiv T_{1k}$

Here neither x_k nor x_k' is necessary for a realization of T.

Case 2:
(a) $T_{1k} \supset T_{0k}$, T_{1k} is said to contain T_{0k}; that is, $T_{1k} \neq T_{0k}$ but if $T_{0k} \equiv 1$ then $T_{1k} = 1$. Under the condition, T_{0k} $T_{1k} \equiv T_{0k}$ and $T_{0k} + T_{1k} \equiv T_{1k}$. Therefore, $T \equiv x_k\, T_{1k} + x_k'\, T_{0k} \equiv x_k\,(T_{0k} + T_{1k}) + x_k'\, T_{0k}$; $T \equiv x_k\, T_{1k} + T_{0k}$
Hence x_k' is not necessary for a realization of T.

(b) $T_{0k} \supset T_{1k}$, T_{0k} is said to contain T_{1k}; that is, $T_{1k} \neq T_{0k}$ but if $T_{1k} = 1$ then $T_{0k} = 1$. By reasoning similar to case (2a), the variable x_k is not necessary in a realization of T.

Case 3:
Neither of the above cases. For this case no reduction in the number of literals is possible and hence both x_k and x_k' are necessary in a realization of T.

In general, it can be stated that the literal which is the coefficient of a residue that is contained in the other residue is not necessary in a realization of T.

A more fundamental approach to the problem of residue evaluation, and one that eventually leads to a complete residue test by means of a few simple rules, is based upon a matrix of combinations for T.

Given a transmission function T, we can construct a matrix, from the $(n+1)$ variables of T, with $(n+1)$ columns and $2^{(n+1)}$ rows such that one variable heads each column and each row is one of the $2^{(n+1)}$ possible states of the variables, taken collectively. Pre-augment the matrix by a d-column that has for elements lying in a given row of the original matrix, the decimal equivalent of the binary number representation of that row. Post-augment the latter matrix with a T-column that has for elements in a given row of the original matrix the state of T corresponding to the state of the variables agreeing with that row of the matrix.

Using the above procedure, example 1 becomes the following matrix:

d	x_3	x_2	x_1	x_0	T
0	0	0	0	0	0
1	0	0	0	1	0
2	0	0	1	0	1
3	0	0	1	1	0
4	0	1	0	0	0
5	0	1	0	1	0
6	0	1	1	0	1
7	0	1	1	1	0
8	1	0	0	0	0
9	1	0	0	1	0
10	1	0	1	0	0
11	1	0	1	1	0
12	1	1	0	0	0
13	1	1	0	1	1
14	1	1	1	0	0
15	1	1	1	1	1

In general, the matrix of combinations will be a 2^{n+1}x $(n+3)$ matrix.

If p of the elements in the T-column are in the 1 state the $2^{n+1}-p$ of the elements in the T-column are in the 0 state. Disregard the rows of the matrix of combinations that

have a *0* in the *T*-column. Nothing is lost by doing this since we know the states of $x_n, \cdots, x_0$ for which $T = 1$ and T must be *0* for all other states of $x_n, \cdots, x_0$. At this point a *px (n+3)* matrix remains. In example 1 this matrix becomes:

d	x_3	x_2	x_1	x_0	*T*
2	*0*	*0*	*1*	*0*	*1*
6	*0*	*1*	*1*	*0*	*1*
13	*1*	*1*	*0*	*1*	*1*
15	*1*	*1*	*1*	*1*	*1*

If *q* of the elements of the *p*x *(n+3)* matrix have a *1* in the x_k column, where x_k is the variable being tested for necessary appearance in a representation of *T*, then *(p-q)* of the elements in the x_k column are *0*. Shift the rows of the *p*x *(n+3)* matrix so as to partition it into *q* rows with all *1*'s in the x_k column and the remaining *(p-q)* rows with all *0*'s in the x_k column.

In example 1 this matrix is (upon inspecting the x_1 column):

d	x_3	x_2	x_1	x_0	*T*
2	*0*	*0*	*1*	*0*	*1*
6	*0*	*1*	*1*	*0*	*1*
15	*1*	*1*	*1*	*1*	*1*
13	*1*	*1*	*0*	*1*	*1*

By disregarding the x_1 column of the partitioned matrix, since the necessary appearance of x_1* is being tested, it is seen that

$$T_{11} \equiv x_3' x_2' x_0' + x_3' x_2 x_0' + x_3 x_2 x_0$$

and

$$T_{01} \equiv x_3 x_2 x_0$$

where T_{11} and T_{01} have as many terms as there are rows in the partitioned matrix with *1*'s and *0*'s respectively, in the x_1 column. Each term of T_{11} and T_{01} corresponds to a row of the partitioned matrix and is composed of the product of all the variables except x_1, with the variable unprimed if a *1* is in the column corresponding to the particular variable and with the variable primed if a *0* is in the column corresponding to the particular variable. By using the results of case 2 of the residue test given previously, it is seen that no x_1' literal is necessary in a realization of *T*.

In general, T_{1k} and T_{0k} can be formed when the partitioned *px (n+3)* matrix is found from a specified *T*. By applying the cases of the residues test to T_{1k} and T_{0k}, the unnecessary literals, if any, can be found.

A compact and precise expression for representing the *T* given in example 1 is Σ *(2,6,13,15)*. That is, *T* is specified by the sequence of decimal integers for those rows of the matrix of combinations for which $T = 1$. This is called the standard sum form of *T*.

Example 2:

$$T(x_3 x_2, x_1, x_0) \equiv \Sigma\,(14) \equiv x_3 x_2 x_1 x_0'$$

At first sight, the latter procedure may appear quite lengthy. However, this is not actually the case. The length is due to two causes: 1) an introduction to the fundamental theory with its nomenclature, mechanics and many details which with a little practice can become automatic; and 2) lack of a quick knowledge regarding whether a *0* or a *1* occurs in a particular row of the *p*x *(n+3)* matrix corresponding to the x_k column.

Now a procedure will be developed which circumvents the need to use the binary representation of *T* and which allows the direct results from the decimal specification of *T* alone; and in fact, does away with the need for a conversion table from decimal to binary numbers in order

to effect the location of the *1*'s and *0*'s when given the decimal number.

Decimal Procedures

Consider a Boolean function T of $(n+1)$ variables, expressed by $T \equiv \Sigma\,(D)$, where D is the set of decimal integers representing the rows of the matrix of combinations for which $T = 1$.

The decimal integer d will be said to contain 2^k in its binary number representation if $b_k = 1$ in the following identity:

$$d = \sum_{k=1}^{n} b_k\ 2^k$$

If a is a real number let [a] denote the greatest integer not exceeding a. Under the above conditions:

lemma: The decimal integer d contains 2^k in its binary number representation if and only if $[d \cdot 2^{-k}]$ is odd. The proof of the lemma is given in appendix I.

Example 3:

Let us see if 78 contains 4 in its binary number representation.

$$\left[\frac{78}{2^2}\right] \equiv [19\tfrac{1}{2}] = 19 \text{ which is odd.}$$

Therefore 78 does contain 4 in its binary number representation. In fact, 78 is 1 0 0 1 1 1 0 in binary form, where the 1 in the third position from the right indicates the presence of a 4.

Example 4:

Let us see if 105 contains 4 in its binary representation.

$$\left[\frac{105}{4}\right] \equiv [26\tfrac{1}{4}] = 26 \text{ which is even.}$$

Therefore 105 does not contain 4 in its binary representation. In fact, 105 is 1 1 0 1 0 0 1 in binary form, where the 0 in the third position from the right indicates the absence of a 4.

By means of the above lemma, it is possible to rapidly determine whether or not a given integer contains 2^k in its binary representation. It is convenient to define $p_k = [d \cdot 2^{-k}]$ as the placement quotient (pq) of d with respect to 2^k, where $d \epsilon\ D\ in\ T = \Sigma\,(D)$.

The decimal procedure for performing a residue test is the following:

(A) Let D' denote the subset of D with odd pq's. Associate x_k with the set D'. Let D'' denote the subset of D with even pq's. Associate x_k with the Set D''.

(B) Add 2^k to each member of D''. Call this set $\hat{D}$. (Equivalently subtract 2^k from each member of D'. Call this set $\hat{D}$.)

(C) Examine D' and $\hat{D}$ for inclusion relations. (Equivalently examine D'' and $\hat{D}$ for inclusion relations). By the above procedure. T has been put in the form of the identity given by (3).

(D) If

$$D' \supset \hat{D}$$

or

$$\hat{D} \supset D''$$

then x_k' is not necessary in a realization of T. If

$$\hat{D} \supset D'$$

or

$$D'' \supset \hat{D}$$

then x_k is not necessary in a realization of T.

Example 5: (See below).

Check the leading and trailing variables (x_1 and x_6, respectively, in this example) first, since they are tested almost by inspection.

Example 5:

$T\,(x_1, x_2, x_3, x_4, x_5) \equiv \Sigma\,(2, 3, 4, 5, 6, 7, 12, 13, 22, 23, 30, 31)$
where, of course, $D \equiv 2, 3, 4, 5, 6, 7, 12, 13, 22, 23, 30, 31$

(1) Checking x_4* first:

$$\underset{,k}{[\frac{d}{}]} \equiv \underset{,4}{[\frac{d}{}]} \equiv \underset{16}{[\frac{d}{}]},\ d \epsilon D.$$

each $d < 16$ gives $\underset{16}{[\frac{d}{}]} = 0$, even pq

each $d \geq 16$ gives $\underset{16}{[\frac{d}{}]} = 1$, odd pq.

hence $D' = 22, 23, 30, 31$
and $D'' = 2, 3, 4, 5, 6, 7, 12, 13$
also $\bar{D} = 18, 19, 20, 21, 22, 23, 28, 29$

and $\hat{D} = 6, 7, 14, 15$

Since $D' \not\supset \bar{D}$ and $\bar{D} \not\supset D'$, Case 3 of the residue test holds. Therefore both x_4 and x_4' are necessary in a realization of T. (Comparing D'' and $\hat{D}$ one gets the same results).

(2) Checking x_0* next:

$$\underset{,k}{[\frac{d}{}]} \equiv \underset{,0}{[\frac{d}{}]} = d,\ d \epsilon D.$$

Hence $D' = 3, 5, 7, 13, 23, 31$
and $D'' = 2, 4, 6, 12, 22, 30$
also $\bar{D} = 3, 5, 7, 12, 23, 31$
and $\hat{D} = 2, 4, 6, 12, 22, 30$

Since $D' \equiv \bar{D}$, Case 1 of the residue test holds and neither x_0 nor x_0' are necessary in a realization of T. (Comparing D'' and $\hat{D}$ one gets the same results).

(3) Checking x_3* next:

$$\underset{,k}{[\frac{d}{}]} \equiv \underset{,3}{[\frac{d}{}]} \equiv \underset{8}{[\frac{d}{}]}, d \epsilon D.$$

Hence $D' = 12, 13, 30, 31$
and $D'' = 2, 3, 4, 5, 6, 7, 22, 23$
also $\bar{D} = 10, 11, 12, 13, 14, 15, 30, 31$
and $\hat{D} = 4, 5, 22, 23$

Since only $\bar{D} \supset D'$, Case 2 of the residue test holds. Since D' is associated with x_3, x_3 is not necessary but x_3' is necessary in a realization of T.

(4) Checking x_4* next:

$$\underset{,k}{[\frac{d}{}]} \equiv \underset{,2}{[\frac{d}{}]} \equiv \underset{4}{[\frac{d}{}]},\ d \epsilon D.$$

Hence $D' = \underset{31}{4, 5, 6, 7, 12, 13, 22, 23, 30,}$
and $D'' = 2, 3$
also $\bar{D} = 6, 7$
and $\hat{D} = 0, 1, 2, 3, 8, 9, 18, 19, 26, 27$

Since $D' \supset \bar{D}$, Case 2 of the residue test holds. Since $\bar{D}$ is associated with x_2', x_2' is not necessary but x_2 is necessary in a realization of T.

(5) Checking x_1* next:

$$\underset{,k}{[\frac{d}{}]} \equiv \underset{,1}{[\frac{d}{}]} \equiv \underset{2}{[\frac{d}{}]},\ d \epsilon D.$$

Hence $D' = 2, 3, 6, 7, 22, 23, 30, 31$
and $D'' = 4, 5, 12, 13$
also $\bar{D} = 6, 7, 14, 15$
and $\hat{D} = 0, 1, 4, 5, 20, 21, 28, 29$

Since $D' \not\supset \bar{D}$ and $\bar{D} \not\supset D'$, case 3 of the residue test holds and both x_1 and x_1' are necessary in a realization of T.

Appendix 1

Theo: $P_k \equiv C_k \pmod{B}$, $k = 1, 2, \ldots n$

Proof: $d = C_n B^n + \ldots + C_{k+1}B^{k+1} + C_kB^k + C_{k-1}B^{k-1} + \ldots + C_0$

$$\frac{d}{B^k} = \sum_{i=1}^{n-k} C_{i+k} B^i + C_k + \sum_{i=1}^{k} C_{k-i} B^{-i}$$

Put $f_k = \sum_{i=1}^{k} C_{k-i} B^{-i}$; *since*

max $C_{k-i} = B-1$, then

$$0 \leq f_k \leq (B-1) \sum_{i=1}^{k} B^{-i}$$

Hence for every finite k

$$0 \leq f_k < (B-1) \sum_{i-1}^{\infty} B^{-i} =$$

$$(B-1) \frac{\frac{1}{B}}{1-\frac{1}{B}} = 1$$

Putting $S_k = \sum_{i=1}^{n-k} C_{i+k} B^i$ notice that

$S_k = B \cdot S_{k+1}$, hence

$$P_k \equiv \left[\frac{d}{B^k}\right] \equiv S_k + C_k \equiv B S_{k+1} + C_k$$

Therefore $P_k \equiv C_k \pmod{B}$.

Appendix II

If T is expressed in standard product form (in terms of the zeros of transmission) as

$$T = \pi (D),$$

where D is the set of decimal integers representing the rows of the matrix of combinations for which $T = O$, it is only necessary to interchange the association of x_k and x_k' relative to D' and D'' to effect a residue test. The inclusion relations then follow as before.

Summary

For reasons of economy it is advantageous to synthesize switching circuits with as few components as possible. This paper develops a decimal procedure which serves as a necessary condition for realizing a minimum-component circuit. Thus, if a circuit is found, with the specified logical properties, using only the number of components defined by the procedure, it is known that one could not realize any circuit with the specified logical properties using fewer components. In this sense, a lower bound to the number of components needed in the realization of a circuit with specified logical properties is established.

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WELLCOMIA PEROGNATHI N. SP. (NEMATODA: OXYURIDAE) FROM POCKET MICE, *PEROGNATHUS INTERMEDIUS (MERRIAM,* 1889) OF THE GRAND CANYON, ARIZONA

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Introduction

A species of nematode with the general characteristics of the Syphaciinae was recovered from 13 of 26 *Perognathus intermedius* examined during a 1954 expedition to the Grand Canyon National Park, Coconino County, Arizona. A vulva anterior to the middle of the body of the female, the subulate tail, and the absence of cuticular mamelons in the male indicated that these oxyurids belong to the genus *Wellcomia* Sambon, 1907. Further preliminary examination strongly indicated that the specimens differed from the other described species of *Wellcomia.* The differential study of the nematodes was therefore undertaken.

The expedition was sponsored by the Natural History Museum of the University of Illinois. It was organized and directed by Dr. Donald F. Hoffmeister, Director of the museum. Three hundred and ninety-six animals were examined for parasites. Mammals from ten families of three orders were represented. Every effort was made to examine representatives of all species of these mammals.

Acknowledgments

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Sincere thanks are expressed to the mammalogists of the expedition, including Drs. Donald F. Hoffmeister, University of Illinois, W. Z. Lidicker, University of California at Berkeley, W. H. Davis, University of Minnesota at St. Paul, and to Messrs. K. N. Nelson, Chicago, Illinois, and W. Goodpaster, Cincinnati, Ohio, for the collection and identification of the mammals. Gratitude is also due Miss Alice Boatright, Technical Illustrator of the Zoology Department, University of Illinois, for her enthusiastic cooperation in preparing the illustrations.

Materials and Methods

The individual organs of the mammals were examined separately. Parasites were segregated in accordance with tentative identification and individual host. The nematodes were killed in hot 70% alcohol when field conditions permitted or at prevailing temperatures in the absence of an adequate source of heat. They were preserved in 70% alcohol to which 5% glycerine was added upon the return to Urbana, Illinois. Subsequent procedures necessitated further segregation, but the identity of the source and association of the specimens were carefully maintained.

Skins and skulls of host animals are preserved in the University of Illinois Natural History Museum. Final identification of hosts, as reported herein, was made by Dr. Hoffmeister and his staff. Type hosts are identified in this report by the number assigned to them in the museum collections.

Observations

Wellcomia perognathi n. sp.

Description: *Males* (parenthetics indicate average values): length, 2.4-3.48 mm. (3.0); width, 0.259-0.348 mm. (0.314); anterior esophagus, 0.278-0.343 mm. (0.313) by 0.042-0.057 mm. (0.051); esophageal bulb, 0.095-0.116 mm. (0.108) by 0.095-0.116 mm. (0.102); total length of esophagus, 0.391-0.459 mm. (0.421); distance from anterior end to excretory pore, 0.770-0.990 mm. (0.850), to nerve ring, 0.105-0.192 mm. (0.143), to end of cervical alae, 0.270-0.532 mm. (0.442); length of tail, 0.037-0.042 mm. (0.039); length of spike-like posterior cuticular projection of tail, 0.132-0.166 mm. (0.147); length of caudal alae, 0.047-0.066 mm. (0.055); length of spicule, 0.095-0.110 mm. (0.105); length of gubernaculum, 0.018-0.023 mm. (0.021). One pair of large preanal, one pair of lateral, a single median postanal, and paired, large bursal papillae are present.

Proportions: Length/width, 5-8; length/total esophagus, 6-10 (7); length of anterior esophagus/width of anterior esophagus, 5-8 (6); length/length of tail, 50-90 (74); length/distance from anterior end to excretory pore, 3-4 (3.5); length/distance from anterior end to nerve ring, 16-34 (21); length of esophageal bulb/width of bulb, 0.95-1.1 (1.0); length/length of spicule, 22-37 (27.5); length of spicule/length of gubernaculum, 4-6 (5).

Description: *Gravid females* (parenthetics as above): Length, 10.04-15.8 mm. (11.21); width, 0.331-0.441 mm. (0.366); anterior esophagus, 0.499-0.557 mm. (0.534) by 0.081-0.103 mm. (0.092); bulb of esophagus, 0.132-0.158 mm. (0.145) by 0.147-0.176 mm. (0.162); total length of esophagus, 0.631-0.715 mm. (0.679); distance from anterior end to nerve ring, 0.158-0.198 mm. (0.175), to excretory pore, 179-185 mm. (182), to vulva, 3.53-4.8 mm. (4.3), to end of cervical alae, 0.174-0.708 mm. (0.381); length of tail, 1.29-1.53 mm. (1.38); eggs, ovoid, flattened on one side, 0.089-0.105 mm. (0.098) by 0.029-0.037 mm. (0.031), side view, 0.026-0.029 mm. (0.027).

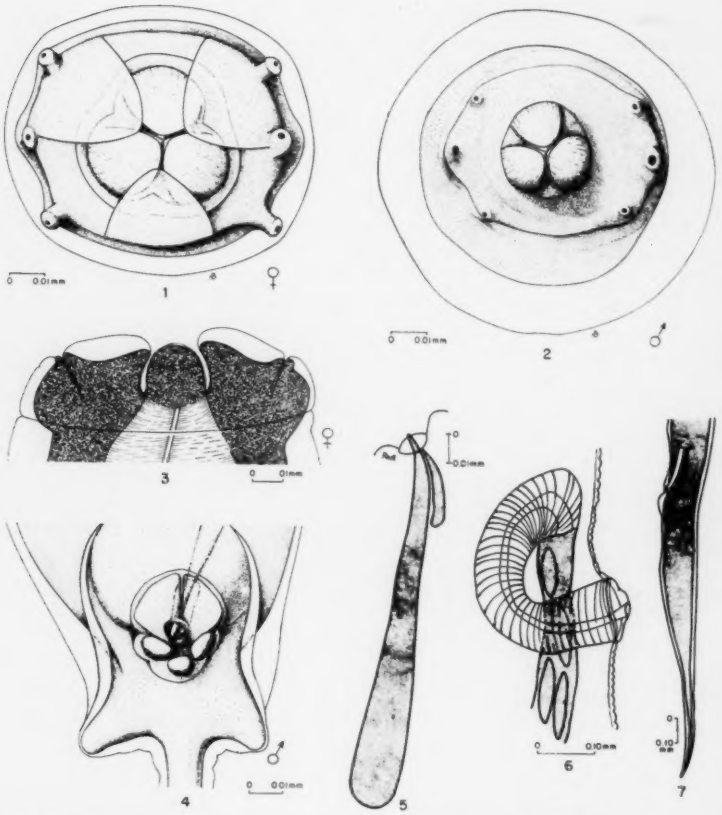
Proportions: Length/width, 28-39 (35); length/total esophagus, 14-24 (19); length of anterior esophagus/width of anterior esophagus, 5-7 (6); length/length of tail, 7-10 (9); length/distance from anterior end to nerve ring, 54-95 (73); length/distance from anterior end to excretory pore, 7.8-8.5 (8.1); length of esophageal bulb/width of bulb, 0.8-1.0 (0.89); length/distance from anterior end to vulva, 2.4-3.7 (2.9); length of egg/width 2.8-3.2 (2.9).

Host: *Perognathus intermedius* (Merriam, 1889). Ill. Nat. Hist. Mus. No. 10602.

Habitat: Intestine (cecum).

Locality: Coconino County, Arizona (Grand Canyon National Park).

Holotypes: U.S. Nat'l. Mus. Helm. Coll. No. 38306.



Wellcomia perognathi n. sp. Fig. 1.—Head, *en face*, female; Fig 2.—Head, *en face*, male; Fig. 3.—Head, lateral view, optical section, female; Fig. 4.—Posterior end, ventral view, male; Fig. 5.—Spicule and gubernaculum, lateral view; Fig. 6.—Vagina-vulva complex, lateral view; Fig. 7.—Tail, lateral view, female.

Remarks: Fifteen mature males and 13 gravid females were analyzed in detail for the preceding characterization. All females less than 10 mm. in length were non-gravid.

Six readily visible structures surround the mouth opening (Fig. 1) of female *W. perognathi*. Three of these correspond to the divisions of the immediately underlying, triradiate esophagus. Therefore, one is dorsal and two are subventral in location. The three remaining, lobed structures partly overlie and alternate with these and include two subdorsal and one ventral units. In accordance with the terminology employed by Smith (1908) for *O. evo-*

luta (=*W. evaginata*), the dorsal and subventral units are lips while the subdorsal and ventral units are liplike (interlabial ?) units. In the contrary terminology of Hall (1916: 70) for the same species, the subdorsal and ventral units are lips, the others "intermediate lip structures". The latter appear to be the proper interpretation for female *W. perognathi.*

Three relatively large units surround the mouths of male *W. perognathi* (Fig. 2). These correspond to the closely associated parts of the triradiate esophagus. One is thus dorsal and two are subventral. Small, triangular thickenings between their bases may represent the alternating (two subdorsal, one subventral) prominent labial structures of the female. A thin, non-lobate, slightly irregular membrane encircles the circumoral units of the male. It may attach to the bases of the small "thickenings". Further study of the circumoral apparatus in the genus *Wellcomia* is needed.

The cuticular lining of the esophagus is corrugated, giving the appearance of small teeth when seen in optical section. All our specimens possess this corrugation, apparently regardless of the state of contraction of the worms.

Three pairs of outer circumoral papillae (Figs. 1, 2) are present in both sexes. The middle unit of each group is amphidial. A lateral papilla and an amphid associate with each subdorsal labial unit of the female; the remaining papilla appears to be located at the base of the subventral unit. Corresponding papillae in the male appear to be similarly situated, but the loss or reduction of labial units obscures parallel interpretation.

The spicule and gubernaculum are chitinized. The spicule is enlarged proximally and slightly recurved ventrally. The gubernaculum is moderately heavy, club-shaped, and grooved toward the spicule except at its innermost end. The distal portion is gently curved ventrad and ends in two small but distinct lateral processes or points. It parallels the course of the spicule (Figs. 4, 5). No specialization of the posteroventral cuticula of the male specimens, such as noted for *W. evaginata*, is present.

The vagina of *W. perognathi* is never everted. The terminal 0.064 mm. are cuticularized. The vagina enters the vulva at right angles to and across the long axis of the body. The terminal uterus (Fig. 6) loops anterior to the vulva, entering the vagina from its anterior aspect.

The tails of female *W. perognathi* are elongate and pointed (Fig. 7) but no spiral markings, as described for *W. evaginata*, are present.

Discussion

The males of *W. perognathi* are smaller than the males of all other described species of *Wellcomia* except *W. taylori* Abdussalam, 1938. They are distinctly larger than the males of the latter. The spicule and gubernaculum are smaller than in all other described species of *Wellcomia* with the exception of *W. evaginata.* They reach the minimum described for the latter species as described by Hall (1916) but are smaller by two-thirds than comparable structures described by Mao (1939). Numerous other differences

confirm the identity of these forms.

The females of *W. perognathi* are the only members of the genus, except *W. taylori,* whose vaginae do not evert. The females of the former are appreciably longer. The eggs of *W. Perognathi* are larger than those of any other described species of *Wellcomia* except *W. longejector* Hannum, 1943. They are smaller than the eggs of the latter species. Other differences are also present.

W. longejector was described from a wide variety of rodents in Arizona. These include the cottontail rabbit "(*Sylvilagus audubonii*)" . . . "the jackrabbit (*Lepus alleni*), the domestic rabbit (*Lepus cuniculus*), pocket mice (*Perognathus baileyi, P. intermedius* and *P. penicillatus*) and the kangaroo rat (*Dipodomys merriami*)" according to Hannum (1943: 50). Its presence in pocket mice in Arizona makes necessary a clear and more detailed differentiation from *W. perognathi.*

The males of *W. perognathi* differ from the males described by Hannum (*op. cit.*) in their sexual dimorphism of labial structure, presence of caudal alae, presence of distinct gubernaculum placed along distal portion of spicule, and in possession of a different complex of caudal papillae. The females of *W. perognathi* do not have the everted vagina so prominent in *W. longejector;* the circumoral papillae of *W. perognathi* are prominent and no dentition is visible at the opening to the esophagus. Thus *W. perognathi* clearly differs from *W. longejector.*

The wide distribution in its various hosts, the question concerning even the presence of a gubernaculum (Hannum, 1943: 51), and the nature of its tail indicate that further study of *W. longejector* should be undertaken.

Summary

Wellcomia perognathi n. sp. is described from the pocket mice of the Grand Canyon National Park, Coconino County, Arizona. The differentiation of this species of oxyurid from other members of the genus *Wellcomia* is presented.

The sexual dimorphism described for the oral apparatus of *W. perognathi* is the only described instance of this phenomenon in the genus. It renders precise interpretation of the labia difficult and indicates need for further study of the oral apparatus of other members of the genus. This is more apparent when one considers the several interpretations of the oral apparatus of *W. evaginata* presented by Smith (1908) and Hall (1916) as noted above (see also Mao, 1939, and Olsen and Tolman, 1951, for further interpretations).

The desirability of further studies of *W. longejector* is indicated.

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EFFECTIVENESS OF A CROW TRAP IN INDIA

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Crows are numerous in India. They serve as scavengers and as consumers of weed seeds and insects, but most observers agree that the harm they do far exceeds the good. Crows are voracious eaters of fruits, vegetables and partially ripened maize grain, sorghums and millets. According to Allen (1931) crows require, at least, half their own weight of food each day merely to exist, and they can easily consume food equivalent to their full weight. Smaller adult crows weigh approximately one-half pound each. Assuming that one-half of the four ounces of food taken per day per crow consists of material which man could eat, in the course of a year, a single crow would appropriate 45 pounds of human food.

The author was confronted with the crow problem while participating in the maize improvement program of the Allahadbad Agricultural Institute in north-central India. To have valuable breeding material destroyed when the crop is almost ready to harvest is serious indeed. Employment of a watchman to scare crows away has only temporary value. The crows learn to feed on the unguarded side of the field until the watchman approaches. What is needed is a method of crow destruction.

Construction of Crow Trap

A trap described by Kalmbach (1939) had proved successful in the United States and in Australia where the trap had its origin. The workshop of the Agricultural Institute made a trap patterned after the one described by Kalmbach. It consisted of a frame made of 1- by 3-inch boards, a ground dimension of 10 by 10 feet, and a height of 6 feet at the corners. From the corners the top sloped toward the middle to a height of 4.5 feet from the ground (Fig. 1). The frame was covered with fine-mesh chicken wire except a strip about 18 inches wide running across the middle of the top. This 18-inch space had wooden slats nailed across it at 6-inch intervals. These slats had long spike nails driven through them, the sharp ends extending downward.

Materials necessary for construction of the trap at the Allahabad Agricultural Institute cost approximately $12.50.

Operation of the Trap in India

The trap should be placed within one hundred feet of a tree, high tension wire, a tall building, or other structures on which crows may perch. It must be baited with an attractive food material which will entice crows.

Four crows were used in an experiment to determine their food preferences. Different kinds of feed were exposed in flat quart containers so that crows, confined in a cage, could choose. The amount consumed (Table 1) was determined by weigh-

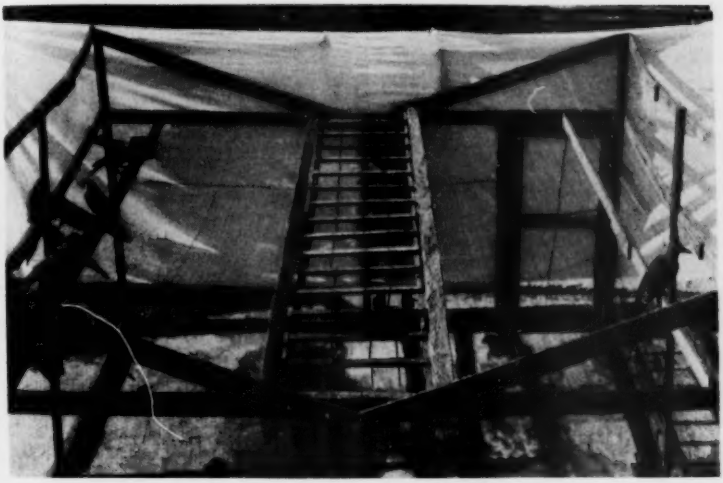

FIG. 1.—Crow trap from above, showing ladder-like strip across top. There is no wire netting over ladder which constitutes a door through which crows may enter. Long spike nails extend downward from rungs to make exit difficult.

ing the feed remaining and calculating the difference.

Although wheat flour proved to be preferred over the other feeds the small amount eaten indicated that dry grain or meal was not attractive enough to entice crows into a trap. Crow numbers at the piggery where garbage from the Institute cafeteria was being fed indicated that garbage might be a desirable bait. Accordingly, we placed fresh garbage which contained a little waste meat, bones, potatoes and other vegetables on the ground in the middle of the trap. Seven days after the trap was so baited several crows entered the trap.

The excited behavior of the outside crows over their imprisoned fellows showed us the importance of leaving decoy crows in the trap. Subsequently, we always left one as a decoy. When the decoy escaped a few days always passed before crows were caught. In order to maintain a decoy at all times, two crows were left in the trap.

EFFECTIVENESS OF THE TRAP IN INDIA

India has two kinds of crows in large numbers. One is the common grey-necked house crow, *Corvus splendens,* Vieillot, and the other, the Indian jungle crow, *Corvus macrorhynchos,* Wagler. The larger jungle crow dominates the common house crow which gives ground readily to its superior companion.

Study of the data in Table 2 suggests that the species of crow caught is influenced by that of the decoy. It also shows that the grey-necked crow will venture into a cage containing attractive food even though his meal will be shared by the antagonistic jungle species.

TABLE 1.—Grain Consumed by Adult Crows in Confinement When Different Foods were Available (grams).

Kind of food	3.5 hours	1 hour	4 hours	Total 8.5 hours
Wheat flour	25.7	14.4	19.8	59.9
Grain mixture	26.7	5.3	3.0	35.0
Wheat bran	7.0	1.4	0.4	8.8
Crushed maize	7.0	0.6	0.2	7.8
Crushed gram (*Cicer arietinum*)	3.7	0.2	0.3	4.2

There were approximately two grey-necked crows to each jungle crow where the tests were made.

The first crow entered the trap on September 1, 1954. The number of crows trapped in the next eight months is presented in Table 3. The number of crows varied widely from month to month, mainly because of difference in care given the trap. Regular attention increased the catch; fresh bait and water in the trap and timely removal of crows were important factors.

Crows visited the trap in largest numbers in the early morning and in the late afternoon. When possible, crows were removed from the trap at 8:30 a.m. and about 4:45 p.m. Crows were collected in a burlap bag and later drowned.

Since the author left India, the crow trap has been in charge of Guru Din Singh, Farm Manager of the Allahabad Agricultural Institute. From August 16, 1955, to February 16, 1956, Mr. Singh caught 1,446, an average of 241 per month. He also made a careful comparison between the larger 10- by 10-foot trap and a 7- by 7-foot trap constructed on the same pattern. These two traps were stationed side by side and baited in the same way. During the six months the large trap caught 1,446 crows, and the smaller one caught only 520, less than half as many. The difference in catch was approximately the same month by month, indicating that large size is an important factor in the successful operation of this type of trap.

TABLE 2.—Relation Between Kind of Crows Used as Decoys and Kinds Trapped.

Crow used as decoys	Number of crows caught		Ratio of jungle to grey-necked crows
	jungle	grey-necked	
Jungle	46	19	1 : 0.4
Grey-necked	86	215	1 : 2.5
Both jungle and grey-necked	7	17	1 : 2.4
Total	139	251	1 : 1.8

TABLE 3.—Number of Crows Trapped in Nine Months, 1954-1955.

Month	Number taken
September	217
October	71
November	318
December	127
January	167
February	149
March	86
April	140
May	24
Total	1299
Average	144

SUMMARY

Crows are numerous in India. They cause economic loss mainly by: a) eating human food; b) destroying seed of new crops in plant breeding plots; and c) entailing the guarding of crops from their depredations.

An Australian cage-trap was effective in catching crows, averaging 144 crows per month in one 9-month period and 241 per month in a 6-month period. An attractive bait and a trapped crow or two in the trap were found essential to induce crows to come into the trap. A trap having ground dimensions of 10 by 10 feet proved about twice as effective as one that was 7 by 7 feet in size.

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PIGMENTS OF THE EMBRYO OF THE YELLOW NELUMBO

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When seeds of most angiosperms are allowed to germinate in complete darkness, the seedlings contain no chlorophyll. If such plants are brought into the light, chlorophyll synthesis takes place rapidly. Smith and Young (1956) have reviewed chlorophyll formation in plants. They reported that etiolated barley or oat leaves will show the presence of chlorophyll within two hours after exposure of leaves to light. However, Lyon (1902) reported green pigments present in the embryo of *Nelumbo*. Arata, in his study of the germination of *Nelumbo* seeds (1958) mentioned that the embryos were green. Meyer and Anderson (1952: 302) stated that "In a few angiosperms such as seedlings of water lotus . . . chlorophyll can also develop in the absence of light."

Methods and Results

Collections of the developing flowers, leaves, and fruits were made from plants of *Nelumbo lutea* (Willd.) Pers. growing in Crab Orchard Lake during the summer of 1957. These tissues, if not examined immediately, were stored at —20° C. until further work could be done. Each time a collection was made, some flowers were examined for the presence of green pigments in the embryo.

Tissues were usually ground in a mortar using 85% acetone with a small amount of calcium carbonate or redistilled ether as the extracting solvent. The extract of the embryo usually had a more yellow cast to it than did leaf extracts. Identification of the chlorophylls was made by simultaneously chromatographing leaf and embryo extracts on the same paper in the same tank. Under these conditions—using a solvent of petroleum ether/acetone (90:10 v/v) the blue-green chlorophyll *a* and the green chlorophyll *b* separated from both extracts.

Four spots of chlorophyll *a* and of chlorophyll *b* were cut from sections of the paper containing the embryo extract, eluted with redistilled ether, and their absorption spectra determined in a Beckmann D.U. spectrophotometer. These, with the spectrum of the crude ether extract of the embryo pigment, are presented in Figures 1, 2, and 3.

When an 85% acetone extract of the pigments was placed on a magnesium oxide column and the various pigments separated by washing the column with 85% acetone, a band of deep yellow formed at the upper end. This pigment was held very tightly, and it remained there after the chlorophylls were carried from the column by the acetone. The column was then extruded from the tube, the yellow band cut out and its properties studied. The substance making up the yellow band was soluble in water. In the presence of a base, the yellow color became more intense; in the presence

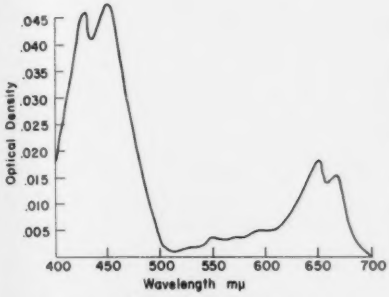

FIG. 1.—Ether extract of embryo of *N. lutea.*

of an acid the yellow color disappeared, leaving a colorless solution.

The yellow pigments were further identified. Water extracts were prepared of leaf tissue, petals, and embryonic tissues. Each extract was shaken with ethyl acetate in a separatory funnel and the water solution discarded. The ethyl acetate was removed under vacuum and the residue taken up in acetone. This acetone extract was used to spot Whatman #1 filter paper. The solvent system used was a mixture of n-butanol/acetic acid/water (6:1:2 v/v/v) and the ascending chromatogram technique was used.

Ten lambda aliquots of each extract were placed on the paper, with 12 spots in all. Paraffin was placed on the cover of the tank, heated, and the paper was fixed thereto. In this manner the paper cylinder was held above the solvent until equilibrium was established between the paper and the vapors of the solvent. After six hours the paper was freed from the paraffin by heat, placed in the solvent, and allowed to stand for 16 hours. Under the highly acidic conditions of the solvent system, the yellow color disappeared. The paper was then removed from the tank, dried at room temperature and placed in a tank in contact with ammonia fumes. In contact with ammonia the yellow color reappeared. In all cases there was evidence for two pigments having Rf values of 0.5 and 0.6.

The paper was further examined for the presence of fluorescent substances. Under ultra-violet light, fluorescent spots appeared in the flower extracts and the extract of the embryo, but there was no fluorescent material found in the leaf extract.

When acetone extracts were reduced to dryness, taken up in ethanol, and treated with metallic magnesium and concentrated HCl, a red color appeared in all cases. The formation of a red color upon reduction of magnesium with concentrated HCl is positive identification of pigments of the flavonoid type (Geissman, 1956).

DISCUSSION

The evidence presented here confirms earlier statements that the embryo of *N. lutea* contains chlorophyll pigments. From the absorption spec-

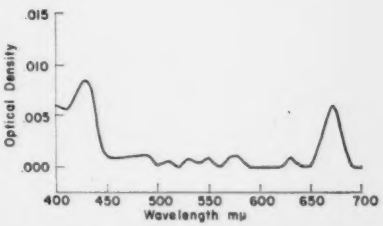

FIG. 2.—Ether extract of chlorophyll *a. N. lutea.*

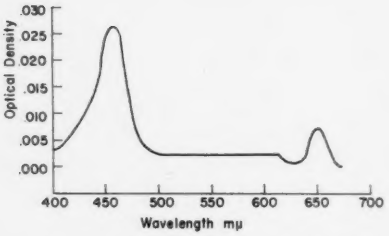

FIG. 3.—Ether extract of chlorophyll *b*, *N. lutea*.

tra presented in Figures 2 and 3, chlorophyll *a* shows two maxima at 430 mu and 665 mu; chlorophyll *b* at 455 and 650 mu. These values are in good agreement with the values published by Zscheile and Comar (1941) for ethyl-ether extracts of spinach leaves. These figures also give some indication of the quantities of the two chlorophylls present. The height of the maxima for chlorophyll *b* is about twice that of chlorophyll *a* in the embryo extract. This fact and the presence of the yellow pigments may account for the strong yellowish cast of all embryo extracts.

As collections were made, the developing ovule was examined for the presence of any green pigment in the embryo. Such pigments could be detected very early in the development of the embryo—almost as soon as the primary leaf could be distinguished. It is difficult to see how any light can come in contact with the young embryo. The pistil has a thick, solid style and the ovary is embedded in a thickened torus. There is a single ovule in the ovary, and the mature "seed" is composed of a very hard ovary wall in contact with the seed coat.

The reactions of the yellow pigments show that we are dealing with an anthoxanthone. It is interesting that the same group of pigments is found in the petal, the embryo, and the mature green leaf. The presence of fluorescent spots in the petal and embryo extract must also be indicative of a close relationship between these two tissues. Paech (1955) has discussed the evidence for the appearance of anthocyanin pigments in young leaves. He has suggested that the flavonoid pigments may be present in leaves but may be masked by other leaf pigments. Here is presented a clear-cut example of the presence of pigments of this kind. These pigments cannot be a product of cell degradation as the leaves collected were mature in a very active condition. The Rf values obtained indicate that the pigments isolated are different from any previously reported (Geissman, 1956).

SUMMARY

The embyro of *N. lutea* contains both chlorophyll *a* and chlorophyll *b*. These pigments are formed early in embryonic development and in the absence of light.

Pigments of the flavonoid type are found in the embryo, the petal of the flower, and the green leaf. The pigments isolated from all three tissues are identical. Fluorescent substances also are present in the extract of the petal and the embryo but are absent in the leaf.

ACKNOWLEDGMENT

I wish to thank Mr. W. Garrison for his help in determining the absorption spectra.

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AN ABNORMAL STERNAL APPARATUS IN A RUFFED GROUSE, *BONASA UMBELLUS*

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and

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Anatomical abnormalities were noted in an immature female ruffed grouse shot by the junior author on October 16, 1955, in Clark County, Wisconsin. After being pointed by a dog and flushed, it flew approximately 15 yards at a height of 5 or 6 feet before being killed. Nothing in the bird's behavior or flight indicated any physical abnormality. However, when the bird was prepared for the table, it was found to exhibit an unusual development of the pectoral region (Fig. 1, left).

Although the pectoral muscles were symmetrical, the entire muscle mass was displaced anteriorly along the coracoids; the mass also extended somewhat farther dorsally on either side. The breast muscles did not extend the usual distance posteriorly and a midline gap separated the muscles of the two sides.

Study of the skeleton revealed a number of atypical conditions. The two halves of the sternum are asym-

FIG. 1.—Ventral views of pectoral musculature of *Bonasa umbellus*. Normal bird is on right.

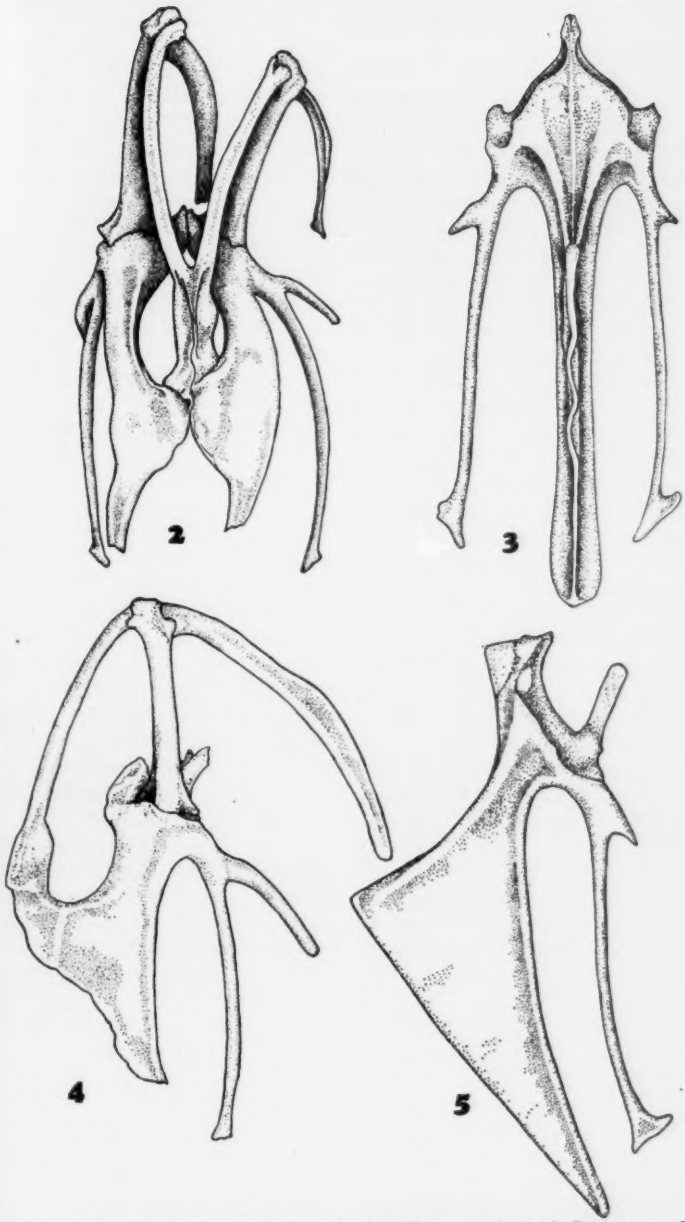

FIG. 2.—Ventral view of abnormal sternal apparatus of *Bonasa umbellus*; FIG. 3.—Ventral view of normal sternum of *Bonasa umbellus;* FIG. 4.—Lateral view of abnormal sternal apparatus of *Bonasa umbellus;* FIG. 5.—Lateral view of normal sternum of *Bonasa umbellus.*

metrical (Fig. 2) and have not fused to form a normal keel; the two halves of the keel touch anteriorly but are widely separated and abbreviated posteriorly. However, a functional keel was formed by the ventrally directed halves of the keel, a posterior extension of the furcular symphysis, and the fusion of this symphysis and the two keel plates. Such fusion is not usual in grouse (Fig. 3).

The sternal plates are generally much reduced in grouse, but in this specimen the median processes or bodies of the left and right plates are unusually small. The left lateral sternal process is normal in position; the right process is placed farther mediad and dorsad than usual. Both processes are normal in configuration except for slightly shorter lengths and considerably heavier bodies. The latter may have developed because of the greater stress on this part of the plate, exerted by the origin there of a greater than usual part of the pectoral mass of muscles.

The dorsal and ventral manubrial processes are reduced and atypical. The costal processes are irregular and indefinite. The large pneumatic foramen usually found on the dorsal surface of the sternal body, just posterior to the dorsal manubrial process or spine, is absent. All parts of the bony sternal apparatus seem to be less pneumatic, although cancellous or spongy bone is visible externally on the dorsal borders of the unfused sternal plates.

The coracoids are normal in size and configuration, but their position is unusual. The left coracoid appears shorter in Figure 2 only because it is directed so far ventrally, but both coracoids deviate from the normal in being more ventrally directed. The more ventral position of the anterior end of the coracoid may be related to the fact that the furculum has been pulled posteriorly to fuse with the ventro-anterior part of the malformed keel. Another deviation is related to the ventral position of the anterior end of the coracoid; the scapula articulates with the coracoid at a less acute angle. This may have been necessary to accommodate shoulder and back muscles attaching to the scapula. The scapulae are of the usual shape but slightly subnormal in length. The clavicles are asymmetrical and twisted to the left; their symphysis is distorted, presumably by fusion to the sternum and by its function as a "substitute keel."

The only additional bones available from this "table-dressed" bird were humeri, ulnae, radii, the proximal two-thirds of the tibiotarsi, the vertebral column posterior to the neck, and the synsacrum. All these, except the latter, appear to be normal. The anterior ends and dorsal borders of the ilia are not completely and normally ossified; cancellous bone is visible on the surface and the transverse processes of the vertebrae do not make contact with the anterior half of the dorsal border of the ilium on either side.

Abnormal bone formation, particularly of the sternum, has been reported frequently. The present instance is significant because: 1) the deviations are apparently not the result of injury; 2) the malformations are restricted to flat bones; and 3) there has been a satisfactory readjustment of muscular attachments and masses to compensate for the severe malformations of bones and to permit normal flight.

A HILLSIDE MARSH IN EAST-CENTRAL ILLINOIS

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General Description of Area

The marsh is located 0.6 mile east and 0.3 mile south of the Route 16 bridge that crosses the Embarrass River east of Charleston, Coles County, Illinois. It consists of approximately one-half an acre situated at the base and lower slope of a hill in a small valley of an intermittent stream flowing directly into the Embarrass River. The marsh is "L" shaped, with one arm at the base of a west-facing slope and the other arm at the base of a north-west-facing slope (Fig. 1). The largest portion of the west marsh area (*i.e.*, adjacent to the west slope) is a flat lowland of standing water in an abandoned stream channel. It affords little drainage and includes a marshy area of seepage on the base of the slope. All of the west marsh area is subject to slight grazing. The north marsh area (*i.e.*, adjacent to the north slope) is somewhat higher on a five to ten percent slope. Although this area is better drained, the soils were saturated and contained some standing water in small depressions throughout 1957. The north marsh area may be divided into three parts according to grazing intensity: heavily grazed, lightly grazed, and ungrazed.

The marsh is fed by cool alkaline seepage water from gravelly deposits in the hill which appear to be parts of an esker on the Shelbyville moraine (Fig. 1). During the winter of 1957-58, water seeping from the hillside formed a four- to eight-inch ice sheet over both areas.

The soil is slightly alkaline and high in organic matter to a depth greater than six feet in the center of the marsh, becoming rather shallow and mixed with alluvial material near the steeper slope. Crust-like cementations of lime and iron up to six inches in thickness are common at the soil surface of most of the north marsh area. These are formed as minerals are precipitated out of the seepage water. The soil near the stream is light sandy alluvium. In late June, 1957, a seven and one-half inch rainfall caused the stream to flood the west marsh area leaving a four- to eight-inch layer of sand on the southern end. This changed the drainage of the area so that this end of the west marsh area contained less standing water than previously.

List of the Vascular Plants

The collection area extended to the limits of the creek on the west, to the border of the marsh on the north, and up to the dryer hillside on the east (Fig. 1). Several marginal herbs were collected, but no attempt was made to include trees of the adjacent forest. The areas were observed every week beginning in March, 1957, and ending in October of the same year. All specimens were placed in the herbarium at Eastern Illinois University. The system of classification was that of Jones (1950). The vascular plants marked with an asterisk have not

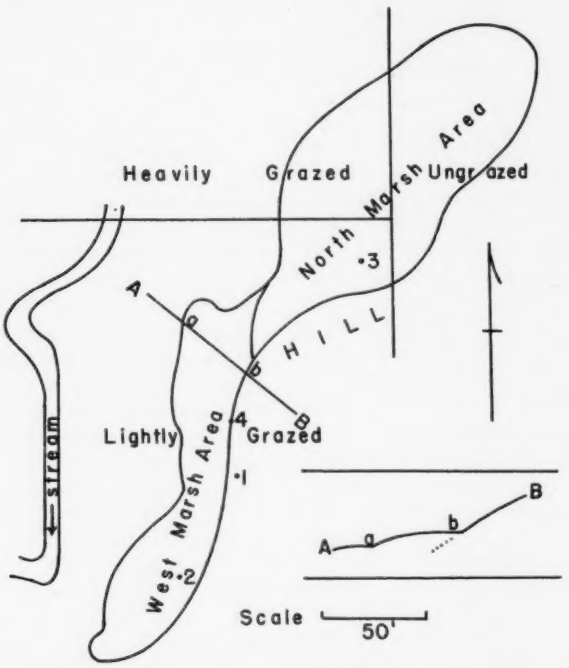

FIG. 1.—Map of marsh showing grazing intensities. Numbered points represent temperature stations. Insert shows approximate profile of line AB on map.

previously been reported for Coles County:

Equisetaceae
Equisetum arvense L.
E. hyemale L.*
Selaginella sp.
Typhaceae
Typha latifolia L.
Alismataceae
Alisma subcordatum Raf.
Sagittaria latifolia Willd.*
Gramineae
Bromus racemosus L.*
Glyceria striata (Lam.) Hitchc.
Sphenopholis obtusata (Michx.) Scribn.*
Cyperaceae
Carex blanda Dewey
C. hystricina Muhl.*
C. lacustris Willd.*
C. lurida Wahl.
C. muhlenbergii Schk.*
C. shortiana Dewey *
C. scoparia Schk.*
C. vulpinoidea Michx.
Cyperus diandrus Torr.*
C. flavescens L.
C. strigosus L.
Eleocharis calva Torr.*
Scirpus atrovirens Willd.
S. validus Vahl *
Commelinaceae
Tradescantia virginiana L.
Juncaceae
Juncus interior Wieg.*
J. tenuis Willd.
J. torreyi Coville
Liliaceae
Trillium recurvatum Beck
Uvularia grandiflora Sm.
Iridaceae
Iris shrevei Small *
Sisyrinchium angustifolium Mill.
Salicaceae
Salix discolor Muhl.
S. nigra Marsh.

Urticaceae
Boehmeria cylindrica (L.) Sw.
Polygonaceae
Polygonum virginianum L.
Nyctaginaceae
Mirabilis nyctaginea (Michx.) MacM.
Portulacaceae
Claytonia virginica L.
Caryophyllaceae
Saponaria officinalis L.
Silene stellata (L.) Ait. f.
Ranunculaceae
Anemone virginiana L.
Caltha palustris L.
Isopyrum biternatum (Raf.) Torr. & Gray
Ranunculus septentrionalis Poir.
Thalictrum dioicum L.
T. revolutum DC.
Berberidaceae
Podophyllum peltatum L.
Cruciferae
Cardamine bulbosa (Schreb.) BSP.
Grossulariaceae
Ribes americanum Mill.
Rosaceae
Agrimonia Pubescens Wallr
Gillenia stipulata (Muhl.) Trel.
Geum canadense Jacq.
Leguminosae
Amphicarpa bracteata (L.) Fern.
A. comosa (L.) G. Don.*
Apios americana Medic.*
Cassia fasciculata Michx.*
Desmodium cuspidatum (Muhl.) Loud.
D. glutinosum (Muhl.) Wood
Geraniaceae
Geranium maculatum L.
Balsaminaceae
Impatiens biflora Walt.
Polygalaceae
Polygala senega L.
Anacardiaceae
Rhus radicans L.*
R. vernix L.
Rhamnaceae
Ceanothus americanus L.
Violaceae
Viola cucullata Ait.*
V. striata Ait.
Onagraceae
Epilobium adenocaulon Haussk.*
Oenothera biennis L.
Umbelliferae
Oxypolis rigidior (L.) Raf.
Primulaceae
Dodecatheon meadia L.
Lysimachia quadriflora Sims.
Gentianaceae
Sabatia angularis (L.) Pursh.
Asclepiadaceae
Asclepias incarnata L.
Convolvulaceae
Convolvulus sepium L.
Polemoniaceae
Phlox glaberrima L.*
P. divaricata L.
Polemonium reptans L.*
Hydrophyllaceae
Hydrophyllum virginianum L.
Boraginaceae
Lithospermum canescens (Michx.) Lehm.
Verbenaceae
Phyla lanceolata (Michx.) Greene.
Verbena striata Vent.
V. urticaefolia L.
Labiatae
Agastache nepetoides (L.) Ktze.*
Blephilia hirsuta (Pursh) Torr.
Monarda fistulosa L.
Pycnanthemum incanum (L.) Michx.
P. pilosum Nutt.
Solanaceae
Physalis pumila Nutt.
Scrophulariaceae
Chelone glabra L.*
Lindernia anagallidea (Michx.) Raf.*
Gerardia tenuifolia Vahl
Mimulus ringens L.*
Pedicularis lanceolata Michx.
Penstemon digitalis Nutt.
Scrophularia marilandica L.
Veronica connata Raf.*
Acanthaceae
Ruellia strepens L.
Phrymaceae
Phryma leptostachya L.
Caprifoloaceae
Triosteum perfoliatum L.
Campanulaceae
Campanula americana L.
Lobeliaceae
Lobelia siphilitica L.
Compositae
Achillea millefolium L.
Erigeron annuus (L.) Pers.
E. philadelphicus L.
Eupatorium coelestinum L.
E. perfoliatum L.
E. purpureum L.
Helenium autumnale L.
Helianthus annuus L.*
Rudbeckia hirta L.
Silphium perfoliatum L.
Vernonia altissima Nutt.

Summary: families — 46; genera — 86; species—111.

Ecological Description

The richness of the vegetation of the marsh varied with the amount of grazing, so that not all the associations are as they would be in their natural state. Black willow, *Salix nigra*, is dominant around the better drained portions of both marsh areas and decreases in importance toward the more poorly drained portions. The largest specimens were eight to ten feet tall and occurred adjacent to the hillside and in the ungrazed area. Pussy willow, *Salix discolor*, was an occasional associate with the larger black willows, but did not seem to be reproducing. At the extreme boundary of the west marsh area were occasional representatives of *Thalictrum revolutum, Triosteum perfoliatum, Tradescantia virginiana,* and *Equisetum hyemale.* Along the margin of the north marsh area bordering the woodland the following spring species were noted: *Thalictrum dioicum, Tradescantia virginiana, Claytonia virginica, Dodecatheon meadia,* and *Viola cucullata.*

Sedges were definite dominants in open areas during all but the early part of summer. In the saturated regions on the west marsh area, the early spring aspect dominant was marsh marigold, *Caltha palustris,* with *Cardamine bulbosa* as an associate. During the early part of the season *Glyceria striata* and *Sphenopholis obtusata* were abundant in the southern end of the west marsh area. *Eleocharis calva, Penstemon digitalis, Asclepias incarnata,* and *Veronica connata* were common during June and July along the western border of the west marsh area. Later in the season *Cyperus strigosus* replaced *Glyceria* and *Sphenopholis,* and *Helenium autumnale* and *Rudbeckia hirta* replaced *Asclepias.*

On the lightly grazed portion of the north marsh area *Lysimachia quadriflora* was an associate with the sedges during early summer. As the season progressed *Oxypolis rigidior* and *Chelone glabra* became associates to the sedges. In the heavily grazed area of the north marsh area *Cyperus diandrus* and *C. flavescens* were almost exclusive dominants, with the exception of *Sagittaria* in the wetter areas. No species of large plants occurred in this area.

The ungrazed portion of the north marsh area was occupied by more dense vegetation than the rest of the marsh. Black willow was distributed more evenly with the larger willow trees scattered throughout. The abundance of *Apios americana* on the willow made walking about quite difficult in the area. Sedges were abundant in openings between the willow, with *Carex lacustris* being the most abundant species.

Three species not common in East Central Illinois were found in the marsh: poison sumac, *Rhus vernix;* marsh marigold, *Caltha palustris;* and fireweed, *Epilobium adenocaulon.* Only one specimen of poison sumac was living, and it occurred in the ungrazed portion of the marsh. Several dead stumps were observed, and the remaining specimen had several dead branches. Distribution of poison sumac, as reported by Jones and Fuller (1955) and Deam (1940), indicates that it occurs more frequently farther north and east in better developed marshy or boggy habitats (Waterman, 1926), but in

TABLE 1.—Soil Temperatures of the Marsh on Eight Different Days, April to August, 1957.

Station	*Av. temp., F.*	*Temp. range*
1 (dry hillside)	69	57-89
2 (standing water)	64	55-74
3 (willow shade)	62	52-74
4 (point of seepage)	59	51-65

the study area this species is evidently at the limit of its range. The sumac stumps suggest that in recent years conditions must have been less favorable for the growth of this species.

Two specimens of fireweed were found along the north-west border of the west marsh area. These were at least 100 miles south of other reported specimens, Jones and Fuller (1955) and Deam (1940). The occurrence of only two individuals suggests that fireweed may be a relic which may soon be eliminated from the area.

Marsh marigold was abundant throughout a good part of the marsh and occurred in several other cool seepage areas in the valley. The distribution of marsh marigold (Jones and Fuller, 1955; and Deam, 1940) indicates that this species is not common in east-central Illinois and approaches its southwestern limit in Coles County. In the areas of relatively high light intensities marsh marigold appeared largely restricted to standing water, but where shade was provided by willows it was most abundant in areas of little or no standing water. To determine whether soil temperature is a factor in this distribution the the average and extreme soil temperatures were taken at a three-inch depth for eight readings at each of four stations (Fig. 1) from April through August, 1957, (Table 1). The coldest temperatures were where water seeped from the hill (station 4) while the highest temperatures occurred outside the marsh on the dry hill above the seepage (station 1). The shaded areas (station 3) appeared to be cooler than the open areas of standing water (station 2). Ten other temperature stations similar to stations 2 and 3 were observed with comparable results. Since the temperatures of the soil in standing water (station 2) appeared to be slightly higher than the temperatures in the shade (station 3), it may be suggested that the persistence of marsh marigold in the marsh is dependent upon the presence of standing water, or upon cool temperatures maintained by partial shade.

The several communities arranged according to soil drainage and amount of grazing suggest a successional pattern in which sedges were the pioneers in the seepage and the most poorly drained areas. Marsh marigold may be present in this stage as an associate, but it will not reproduce itself where drainage increases. Apparently it is most susceptible to this moisture change if it is in direct sunlight; in some shade it often persists into later stages. Black willow and, in some areas, pussy willow invaded the sedge association. Both species reached a height of eight to ten feet with pussy willow as an associate with the dominant black willow. Pussy willow was not reproducing itself on the marsh as was black willow.

The abundance of many young black willows apparently invading the open marsh, the death of poison sumac, the occurrence of only two specimens of fireweed, and the lack of reproduction of pussy willow all point to a changing environment.

Perhaps this indicates that the species here represented at the limit of their range may eventually die and be replaced by the willow. The willow may even be further replaced by some of the flood plain trees such as sycamore, elm, and box elder which occur along the stream bank. However, the deep organic soil points to the fact that the marsh has persisted for a long time, perhaps since the Pleistocene. If part of the area continues to be protected from grazing and continues to receive cool alkaline seepage, it is very possible that this unique community may be able to persist in this local microenvironment. Under these conditions poison sumac and fireweed might not persist, but marsh marigold would probably continue in the shade of the stunted willow association.

Acknowledgments

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Summary

A unique marsh in east-central Illinois was studied in 1957 from a floristic and ecological viewpoint. Of the 111 species in 46 families collected, 29 species had not previously been reported in Coles County. The marsh contained several species at the limits of their ranges, the persistence of which is dependent upon cool alkaline seepage areas. Succession is thought to occur from an open sedge association to a willow association. Fireweed and poison sumac may disappear, but marsh marigold will probably remain in the willow association if grazing is minimized and if standing water and present temperatures persist.

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THE EUROPEAN POPULATION OF NYASALAND

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Although significant European penetration of Tropical Africa began less than a century ago, today Europeans are widely distributed throughout the area. Relatively large numbers of Europeans are found in Southern Rhodesia, Northern Rhodesia, Angola, Kenya, Tanganyika, and the Belgian Congo. The majority of the Europeans who have gone to tropical Africa during the past century have remained there for a limited period of time in such occupations as traders, missionaries, administrators, and miners. Only since the beginning of the 20th century has there been an increasing number of Europeans who, accompanied by their families, have entered tropical Africa with the intention of establishing permanent residences. The presence of mineral resources has been one of the principal, and certainly the most dramatic, factors attracting Europeans to various sections of tropical Africa. The majority of the Europeans who have entered tropical Africa in connection with mineral exploitation, however, have remained for only a limited period of time.

The primary basis for a more permanent type of European settlement in tropical Africa has been agriculture. The location of land with a potential for agricultural development has, of course, been restricted by environmental conditions. In contrast to valuable mineral deposits, land with a promising agricultural potential has attracted European settlement to a much smaller extent. For example, within the territory of Nyasaland, there are four highland regions which are suitable for European agricultural development and settlement; but in spite of this the European population has remained small, with most of the Europeans confined to a single highland region in the south. The small size and uneven distribution of the European population elsewhere in Nyasaland reflect a variety of factors which include isolation and inaccessibility in terms of existing transportation facilities, lack of valuable mineral resources and, until recently, a lack of government encouragement and sponsorship of settlement.

Size and composition of the European population.—Lake Nyasa was discovered by David Livingstone in 1859, but only a few missionaries and government officials entered the area before Nyasaland was made a British Protectorate in 1891. When the first official census was taken in 1911, there were 766 Europeans. The European population of Nyasaland increased at a relatively slow rate until the end of the Second World War.

Table 1 indicates the changes in the number of Europeans. Northern Rhodesia has an abundance of rich mineral deposits; Table 1 illustrates the effect that mineral resources can exert on the development of European population. Kenya is more of an agricultural settlement, and, although the European

TABLE 1.—Total European Population

Year	Nyasaland	Northern Rhodesia	Kenya
1911	766[1]	1,497[1]	3,175[1]
1921	1,431[1]	3,634[1]	9,651[1]
1931	1,975[1]	13,846[1]	16,812[1]
1945	1,948[1]	20,142[2]	23,033[2]
1950	4,000[2]	36,000[2]	29,660[2]

[1] Official European census.
[2] Official European estimate.

population continued to increase, it was at a slower rate than in Northern Rhodesia. In the relatively prosperous decade between 1921 and 1931 the European population of Northern Rhodesia increased almost four times, Kenya's population nearly doubled, but the increase in Nyasaland was relatively small. It was only after 1945 that a relatively large increase in Nyasaland's European population occurred as the result of a government-sponsored development plan and official encouragement of European immigration. The 1956 census estimated that the European population of Nyasaland was 6,730, in contrast to Northern Rhodesia's 64,810 Europeans.

The composition of the European population in Nyasaland, in terms of the number of males, females, and ages, changed considerably during the period of European settlement. The 1921 European census of Nyasaland indicated a total European population of 1,431, of whom 68.3% (977) were males and 31.7% (454) were females. Furthermore, 14.8% (212) were children under the age of 20. It could be concluded that such a population structure was typical of a pioneer society wherein European adult males predominated. By 1945, the date of the latest available European Census of Nyasaland, the number of Europeans was 1,948, with equal numbers of females and males between the ages of 25 and 65. The paucity of children under the age of twenty noted in 1921 and 1945 was due to the fact that most European families sent their children back to their country of origin. (mainly to Great Britain) for further education. According to the 1956 census, there were 3,710 European males and 3,020 females.

The occupational composition of the gainfully employed Europeans in Nyasaland has remained stable. In 1911 the two largest occupational groups were services, which accounted for 56% of the working population, and agriculture, which accounted for 19% of the workers. In 1950, 58% of the European workers were engaged in services and 22% in agriculture.

Distribution of Europeans. — The European population is unevenly distributed in Nyasaland wherein most of the Europeans have always been located in the Shire Highland (Figs. 1 and 2). In addition to the Shire Highland there are three other areas in Nyasaland which are favorable for European agricultural set-

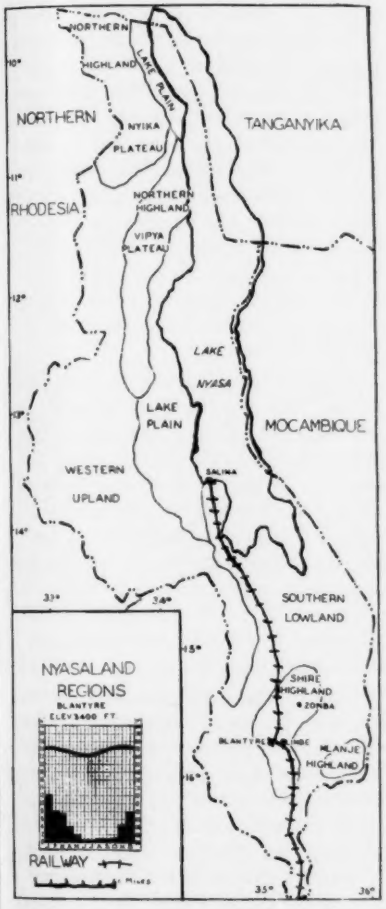

FIG. 1.—Regions of Nyasaland.

tlement: the Western Upland, the Mlanje Highland, and the Northern Highlands. Within each of these areas there is arable land, moderate temperature, and adequate rainfall. On the other hand, in the low-lying Lake Plain, temperatures are high and rainfall is heavy; in the Southern Lowland rainfall is sparse and temperatures are high.

In the Shire Highland the arable land is more than 3,500 feet above sea level with moderate temperatures, extremely fertile soils, and an annual rainfall between 40 and 50 inches. The Shire Highland was the first region of European settlement, primarily because of its accessibility via the Shire and Zembezi rivers. The first railroad penetrated the Shire Highland in 1908 when a line was completed between Blantyre and Port Herald on the Shire River. In 1935 the Zembezi River Bridge was opened and through railroad service was established with the Indian Ocean port of Beira in Portuguese East Africa.

The 1911 European Census, just three years after the completion of the railroad, indicated that 55% of the total European population was located in the Shire Highland. In 1945 (Fig. 2) 62.5% of the 1,948 Europeans were in this region along with the three urban centers of Blantyre, Limbe, and Zomba (the administrative capital).

The most extensive and diversified European agricultural activity has developed in the Shire Highland. In 1922, the principal crops grown by Europeans were tobacco and cotton, more than 10,000 acres each (Fig. 3). Other important crops of the Europeans at that time, in order of acreage, were maize, legumes, and timber. By 1940 the agricultural emphasis had changed; cotton was no longer produced and there had been a considerable decrease in the tobacco acreage. Timber and tea have become the two principal European-produced crops in the Shire High-

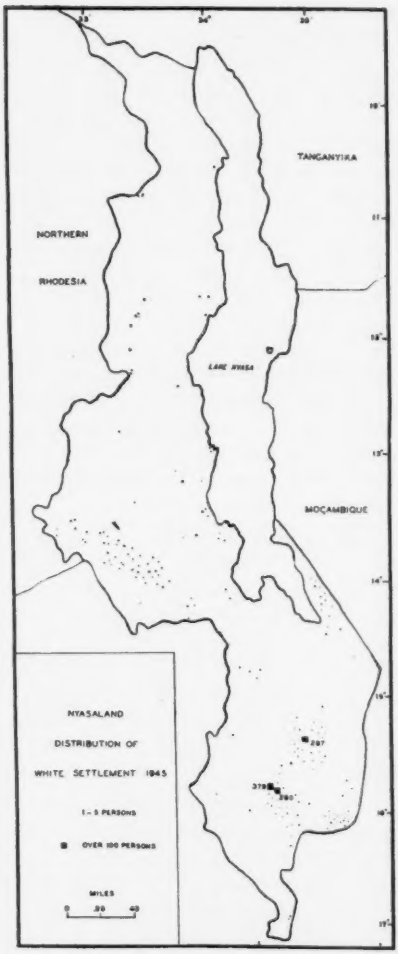

FIG. 2.—Nyasaland: Distribution of white settlement in 1945.

land with about 10,000 acres in each crop. Tea greatly increased in importance, and now the Shire Highland is the principal tea-producing region with over 11 million pounds of tea in 1956. Timber production has remained important, while tung and sisal production have increased.

The second largest group of Europeans (427 in 1945) is in the Western Upland Region. The development of highways between 1932 and 1945 modified the isolation of this region. Here elevations range between 3,000 and 5,000 feet above sea level and the annual rainfall is smaller than in the Shire Highland. Tobacco has been the principal crop in this region, but oil crops (tung and groundnuts) have recently assumed significance.

A small concentration of Europeans (143 in 1945) is located in the isolated Mlanje Highland Region. Within this region there are areas of fertile loam soils and rainfall of about 110 inches annually. Tea has been the major crop produced; in 1956 the Mlanje tea estates produced more than 9,000,000 pounds of tea. Timber has become the crop of second importance, followed by tobacco.

The Northern Highlands Region consists of the Vipya and Nyika plateaus where elevations range between 6,000 and 8,000 feet above sea level. There are only a few Europeans in this area due in part to its isolation by distance and the lack of transportation facilities. Tea production was introduced to this area in 1956 and rubber is produced near the base of the Vipya Plateau where there is an evenly distributed annual rainfall of between 70 and 100 inches.

Agricultural production and exports.—The foreign trade of Nyasaland has been based upon the development of agricultural production. Because many agricultural efforts have been experimental and

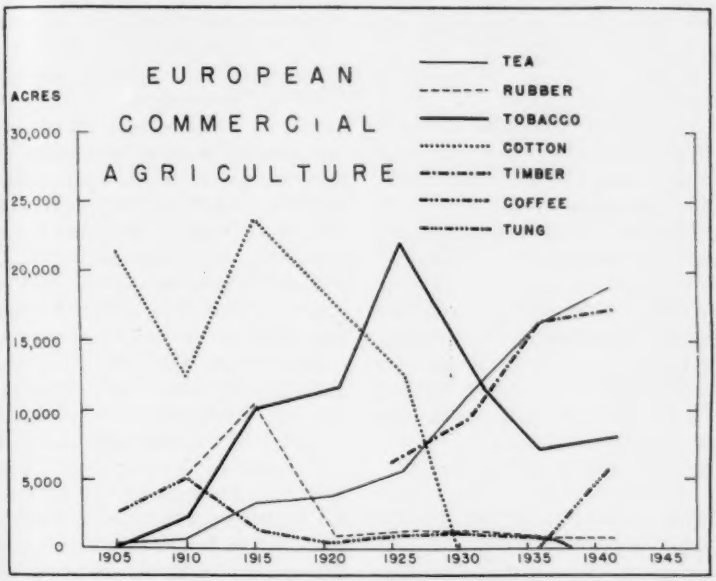

FIG. 3.—European commercial agriculture.

because of price fluctuations in world markets, the importance of various crops has changed and the acreages of most crops have fluctuated considerably. Tea production has steadily expanded and tobacco acreage has increased steadily since 1937. Tobacco, grown primarily in the Western Upland and Shire Highland regions, is the most valuable export crop and in 1956 tobacco exports were worth more than £3,000,000. Tea, produced primarily in the Shire and Mlanje highlands, is the second most important export crop. The value of tea exports in 1956 was £2,900,000. Cotton, once the principal crop of Nyasaland, is no longer produced by Europeans, and coffee and rubber failed to materialize as important crops. Three relatively new crops which have gained significance are timber, tung, and sisal.

The future.—The European population of Nyasaland will probably increase slowly and primarily in connection with increased agricultural development. With extension and expansion of highway transportation facilities, the European population will probably be somewhat more widely distributed, but the general distribution patterns will remain essentially the same. But promising ore with a high uranium content has recently been discovered in Nyasaland. If this, or future discoveries, should prove the presence of valuable mineral reserves, there could be significant increases in the number and distribution of Europeans in Nyasaland.

THE FUTURE STATUS OF THE NUTRIA, FUR-BEARING RODENT, IN ILLINOIS

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Persons are being encouraged to introduce into Illinois the South American rodent known as the nutria, *Myocastor coypus*. Lucrative gains have been promised by breeders' associations to those raising these animals on fur farms. Before extensive introductions are made, however, it is wise to review the facts concerning the nutria and to predict its future value as a fur-bearing rodent in Illinois.

The nutria is native from Paraguay to the Straits of Magellan. It is closely related to the guinea pig and porcupine and is only distantly related to the muskrat. An aquatic rodent weighing as much as 25 to 35 pounds, it resembles a beaver, but has a round, not paddle-shaped, naked tail. The mammary glands are located on the sides rather than on the abdomen. Nutrias are docile and less wary of humans than muskrats or beavers. In many places where nutrias have been liberated, they are active during the daytime; in other places they are active only at night.

Under ideal conditions, nutrias feed almost entirely an aquatic vegetation along the edges of marshes and ponds, or out in these bodies of water. They prefer cattails, reeds, and various other types of aquatic vegetation. Their nests are usually made among reeds and sedges and are built by piling together the cut twigs of these plants, forming a somewhat bird-like nest. Sometimes the animals burrow into banks. The burrows are short and from eight to nine inches in diameter. Nutrias will not eat the algae or water mosses found in many of our ponds and swamps. They are said to clear out this type of "vegetation" but such does not seem to be the case.

Under favorable conditions these animals will breed the year around and each adult female may produce two or three litters each year with an average of five young in a litter. The young are precocial and care for themselves effectively a few hours after birth. They weigh about one-half pound at birth, grow rapidly, and reach sexual maturity in less than six months. Under favorable conditions, nutrias are as prolific as rabbits!

Captive nutrias on fur-farms would not compete with the native muskrats. However, wherever nutrias have been introduced as farm animals, some almost invariably have escaped because of ineffective penning, flood damage to the pens, or other factors. Once free, they could readily establish themselves in nature in many parts of the United States. Their food habits, breeding habits, and general behavior place such nutrias in direct competition with our native muskrat. It seems inevitable that they will usurp much of the food of the muskrat and by their prolificacy outnumber them in a short time.

The nutria has been introduced in

many parts of the world, including most states in the United States, Europe, and Russia. Perhaps its most extensive introduction and fur-farming has taken place in the southern United States. In many places, nutrias have been released in open bodies of water, such as small lakes and ponds, where it was felt that they could naturally feed upon the vegetation choking the lakes and prove beneficial both by clearing out the vegetation and as a source of income from their fur. In some cases, they have soon eaten all shore vegetation. Nutrias, released in one lake in Texas, cleaned away all marginal vegetation, then turned to larger items such as small trees, and most recently have been swimming out into the lake and feeding on the duck-blinds, the supports of which they have completely cut, and caused the blinds to sink.

In many parts of the southern United States, nutrias have become such pests that numerous requests are being made for practical methods of eliminating them. There is no practical method known for removing them. In some states, such as Texas, they can be killed legally at any time and by any method. Nevertheless, they still continue to increase and remain a pest.

Nutrias have not only failed to remove moss from clogged ponds, but their burrowing activities have weakened earthen dams and levies. Their extensive utilization of shore vegetation has forced the native muskrats out of some areas and destroyed valuable waterfowl habitat.

It seems apparent that what has happened in Texas and other southern states with regard to nutrias in the wild may very well happen in Illinois. Although it might be the intention to keep all nutrias in fenced fur farms, it is predictable that circumstances will enable nutrias to escape. It seems probable that in Illinois they would establish themselves along drainage ditches and around ponds in such a fashion that they would be a real menace to the native muskrat and waterfowl. They would compete with other mammals living in marshy areas, including the swamp rabbit, and in general become so numerous as to be a threat to many kinds of wildlife.

Promoters have claimed that the fur of the nutria is far more valuable, in dollars and cents, than that of the muskrat. They maintain that a nutria skin will bring up to $75 and ask as much as $1000 for a pair of breeding nutrias. Actually, nutria pelts are selling for from 25 cents to $2.50 (average about $1.25) on the 1958 fur-market. Furthermore, fur-buyers are hesitant to take nutria pelts even at these low prices. It is unlikely that nutria fur will bring appreciably greater prices in the next few years. The muskrat in Illinois was bringing about $2.50 in 1958, or about twice the average amount for the nutria. The muskrat tends to maintain a satisfactory balance in its habitat and should continue to produce over many years, whereas the introduced nutria all too often "eats itself out of house and home". The end result may be that first the nutria will drive the muskrat out and then drive itself out by destroying all available food.

The National Better Business Bureau, the National Fur News, and

many other organizations have cautioned prospective investors to check the economic aspects of nutria-farming.

Because of the low economic gains from nutria-farming and because of the probable undesirable effects of introducing another non-native mammal which may replace a valuable fur-bearer, it is advisable to exercise careful controls over any importations and plantings of nutria within the state of Illinois. It would seem most desirable to forbid any importations, plantings, and fur-farming of nutria within Illinois.

A PRELIMINARY INVESTIGATION OF THE BINDING ENERGY OF LiH

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In a previous paper, Musulin (1956), an empirical method for the calculation of molecular screening constants was presented. The purpose of this paper is to make an exploratory calculation of the binding energy of the LiH molecule using a wave function containing a molecular screening constant. This type of wave function, containing only one screening constant, is much simpler than conventional wave functions of heteronuclear diatomic molecules which demand the use of two parameters. The simplification is even greater for those calculations including the effect of inner shell electrons of atoms having a principal quantum number equal to or greater than two.

Method of Calculation

The LiH molecule is the simplest diatomic molecule involving electrons of principal quantum number equal to 2. This molecule should provide an excellent test of a molecular screening constant in the place of the individual atomic screening constants suggested by Slater (1930). The molecule has a polar nature and thus provides an excellent test of the effect of ionic terms in a complete wave function.

The simplest approximation is to consider a covalent bond between the 1s electron of the hydrogen atom and the 2s electron of the lithium atom. The 1s electrons of the lithium atom are considered to be part of the nuclear core.

The Hamiltonian operator for the system is given (in atomic units) by 1) below.

A Heitler-London (Valence Bond) approach is used. The wave function of the system being of form 2) below.

Parallel calculations were performed using hydrogenic 2s functions and Slater 2s functions for the lithium atom. They are 3) below.

The energy eigenvalue is calculated by 4) below.

The molecular screening constant is calculated by an equation of form 5) below.

The equilibrium distance is given by Herzberg (1950) as 3.01 a.u. and the calculated molecular screening constant (z) is 1.96. This value is used in both the hydrogen and lithium wave functions, replacing the atomic screening constants of 1.00 and 6.74 for hydrogen and lithium, respectively.

In practice, rather than to apply equation No. 4 directly, it is simpler to determine the expectation values of the kinetic energy (T) and the potential energy (V) and to calculate of the total energy by means of 6) below.

The expectation values are evaluated as functions of ρ in this method.

The various one-center integrals were evaluated as functions of R by direct integrations. The two-center coulomb integrals were evaluated by

1) $$\underline{\underline{H}} = -\tfrac{1}{2}\nabla_1^2 - \tfrac{1}{2}\nabla_2^2 - \tfrac{1}{r_{H_1}} - \tfrac{1}{r_{H_2}} - \tfrac{1}{r_{Li_1}} - \tfrac{1}{r_{Li_2}} + \tfrac{1}{r_{12}} + \tfrac{1}{R}$$

where $-\frac{1}{2}\nabla_i^2$ = kinetic energy of electron i

$-1/r_{a_1}$ = potential attraction between nucleus, a, and electron, i.

$1/r_{12}$ = potential repulsion between electrons 1 and 2

$1/R$ = potential repulsion between the nuclei.

2) $$\Psi\ (1,2) = \Psi_{Li}(1)\,\Psi_{H}(2) + \Psi_{Li}(2)\,\Psi_{H}(1).$$

$$\Psi_H = \frac{1}{\sqrt{\pi}}\ e^{-\rho}$$ Hydrogenic and Slater

3) $$\Psi_{Li} = \frac{1}{4\sqrt{2\pi}}\ (2-\rho)e^{-\rho/2}$$ Hydrogenic

$$\Psi_{Li} = \frac{1}{4\sqrt{6\pi}}\ \rho e^{-\rho/2}$$ Slater

where $\rho = zr$

z = molecular screening constant

4) $$E = \frac{\int \Psi^*_{\underline{\underline{H}}}\ \Psi\ d\tau}{\int \Psi^*\ \Psi\ d\tau}$$

5) $$z = Ae^{-R_e} + B$$

where R_e = equilibrium distance

A,B = empirical constants

6) $$E = z^2T + zV.$$

the method of Rudenberg *et al.* (1956) and the two-center exchange integrals by the method of Rudenberg (1951). The two-center integrals using hydrogenic wave functions were found to be linear combinations of two-center integrals involving Slater functions. In all cases the use of a single screening constant provided a simplification of the integral formulas.

The evaluation of the energy eigenvalue is to be done by a variational procedure involving only the parameter R. A preliminary test of this wave function was made by direct evaluation at the equilibrium distance of $\rho = 5.90$ a.u.

Results

The values of the one-center integrals using hydrogenic wave functions agreed, to less than 10%, with those using Slater functions. The

two-center coulomb integrals differed by a factor of two. The actual numerical value of the hydrogenic coulomb integral is 0.07 and the small absolute value was responsible for the large percentage difference. The two methods of calculation failed to give agreement in the value of the exchange integral. This integral has the value of —0.03 when the Slater functions were used and —0.41 for the hydrogenic wave functions. All values of Slater function integrals were checked by interpolation or extrapolation in the tables of Kotani *et al.* (1938, 1940) and were found to agree with the present calculation.

The binding energy of LiH using Slater functions was found to be 7.99 e.v. and —3.55 e.v. with the hydrogenic function. The observed value, as given by Herzberg (1950), is —2.59 e.v. The present results should be compared to the value of —1.30 e.v. obtained by Yasumori (1952) using atomic screening constants.

A good test of a trial wave function is that the expectation values of the kinetic and potential energies satisfy the virial theorem:

$$\frac{V}{T} = -2 \tag{7}$$

This criterion was applied to the present wave functions. A ratio of —1.1 was obtained with Slater functions and —1.3 with hydrogenic functions.

Discussion

The binding energies found in this approximation are of the correct order of magnitude. These numbers represent the difference between two large numbers, and a slight error in the total energy of LiH causes a large error in the binding energy. The total energy, using Slater functions, is 46% of the observed total energy. This is remarkable if one considers that no account has been made of the ionic nature of LiH, of the hybridization of the 2s Li electron, and of the inner shell electrons.

There appears to be a numerical error in the exchange integral using hydrogenic functions. Not only is the value far different from that obtained with Slater functions, but the binding energy is more negative than the observed value. A theorem of the variation method states that the true energy must be approached from above.

The present calculations show that, if ionic terms, hybridization, etc. are to be included, the amount of work required can be greatly reduced by using a wave function with a single molecular screening constant. The exact degree of usefulness will depend on the rapidity of convergence to the observed value. A variational procedure, with respect to the internuclear distance, must be made to determine the usefulness of the trial function in the simplest approximation as described in this paper. Work is now in progress on these aspects of the calculation.

In order to make a complete test of the molecular screening constant, similar calculations are being performed on Li_2. This molecule is nonpolar in the ground state, and the results of the simplest approximation are expected to be closer to the observed value than in the case of LiH.

Summary

A new trial wave function was used to calculate the binding energy of LiH. The binding energy of LiH, considering the valence electrons only at the observed equilibrium distance, was evaluated in the Heitler-London approximation. The new function used a single molecular screening constant and the resulting calculations were much simpler than with conventional approximate wave functions. The calculation was performed using both Slater atomic wave functions and hydrogenic atomic wave functions. The former gave a value of the binding energy of 7.99 e.v. and the latter of —3.55 e.v.

Acknowledgment

This work was supported in part by the Research Corporation and by the Graduate School of Southern Illinois University.

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ACTIVITIES OF THE JUNIOR ACADEMY OF SCIENCE

A Summer Biology Program, by Elnore Stoldt, Jacksonville High School, Jacksonville, Illinois.

As a result of a request from our students, an advanced biology course was offered in the summer of 1958. It met three days a week for two hours of lectures and discussion; one day each week was spent on an eight-hour field trip. No academic credit was given. Twenty students registered.

The central theme of the course was growth and development of plants and animals. Students experimented with growth-promoting substances in the laboratory, and the analysis of plant growth regulators was completed in the classroom. Dr. Robert A. Evers conducted the field study of hills, sand prairies, and various other habitats near Meredosia.

The St. Louis zoo was visited, and the survival of plants and animals was studied at Marquette State Park. To indicate distribution in different habitats many of the lower plants and animals were collected.

Human biology was investigated by having the students study their own traits such as growth, behavior, tongue curling, and tasting. Serum production for veterinary use was observed in the Cofiliated Laboratories at White Hall. The bacteriological laboratory at Jacksonville State Hospital served for one field study of medical biology. Anthropological procedures were observed at Dickson Mounds State Park.

The State Museum at Springfield was used to study methods of display and to indicate the values of such institutions to the public.

Of special interest in this course was the discussion of the need for critical reading and analysis of news items and other printed materials.

On-the-job Research, by Robert L. Walker, Lyons Township High School and Junior College, La Grange, Illinois.

The primary purpose of such research is to give talented students an opportunity to observe the methods of science. The value each receives is directly proportional to his or her contribution to the investigation.

In November, 1957, our school received one of four pilot grants for on-the-job research from the Future Scientists of America Foundation of the National Science Teachers Association. Seven capable students, four seniors and three juniors, were selected to work with me on the control of the rate of water evaporation through use of monomolecular films. Although all the students were talented, the degree to which they could contribute to the program differed greatly. We met two hours during Monday and Thursday evenings. Dr. John W. Ryzner of the National Aluminate Corporation served as technical advisor.

Two of the three juniors are continuing the project. Students as well as staff are being benefited. Students learn that original ideas are hard to develop, that research is work, and that there is satisfaction in investigating such things. The

high-school teacher is aided in his efforts to keep abreast of the field, to meet the needs of his students, and to offer inspiration to science students.

Trips to Professional Scientific Meetings, by Robert Elias, Canton Senior High School, Canton, Illinois.

Mr. Ronkette, biology instructor, and science club members, Ronald Brons, Charles Rogers, and Robert Elias, attended the Bloomington meeting of the American Institute of Biological Sciences on August 24 to 28, 1958. While in attendance they camped at McCormick's Creek State Park. They were especially attracted to the A.I.B.S. exhibits and the refresher courses in protozoology and teaching methods.

Editorial Notes

The editor wishes to thank the members of the Editorial Board and other readers who have helped in evaluating manuscripts.

It is hoped that the *Transactions* in 1960 will appear as a regular quarterly, with four, separate, full-sized issues. Lack of funds this year has made it necessary to reduce greatly the amount of material published. If the proposed increase in financial assistance materializes, the *Transactions* will contain approximately 400 pages each year.

ACADEMY BUSINESS

SECRETARY'S REPORT OF THE BUSINESS OF THE ILLINOIS STATE ACADEMY OF SCIENCE FOR THE YEAR MAY 4, 1957 TO MAY 10, 1958

Compiled by

ROBERT A. EVERS, *Secretary*

The 51st annual meetings of the Illinois State Academy of Science were held at Urbana, Illinois, on May 9 and 10, 1958, with the University of Illinois as host. The program of the 10 sections included 107 papers, and the total attendance at the section meetings was more than 600.

The general session of Friday morning, May 9, held in the Auditorium, opened with a Welcome by Dr. David D. Henry, President of the University of Illinois. The welcome was followed by the Presidential Address of Dr. Wayne W. Wantland, entitled "Present Status of Man as Host to Animal Parasites."

At 10:45, Walter Warwick Sawyer, Visiting Associate Professor of Mathematics, University of Illinois, presented a very interesting lecture-demonstration entitled "Enlivening Mathematics and Science Teaching."

The Junior Academy again showed continued growth. There were 976 exhibits in the University Armory, judged by approximately 400 judges. Of the 976 exhibits, 93 were considered outstanding. More than 1,200 persons attended the Junior Academy banquet which was held in the Illini Union, University of Illinois. This was the largest banquet ever served at the Illini Union. Senior Academy members set aside the 11:30 a.m. time on the Friday program for visiting the Junior Academy exhibits.

The annual banquet of the Senior Academy was held in the Allen Residence Hall of the University of Illinois. Following the custom of the past several years at the annual banquet, the past presidents were asked to rise. Among those responding were Miss Joan Hunter, Dr. H. R. Wanless, Dr. James Neckers, Dr. George W. Ekblaw, Dr. W. W. Grimm, and Dr. George D. Fuller.

The evening meeting was held in the Auditorium of the University of Illinois. The program was opened by Dr. G. R. Yohe, Chairman of the Science Talent Search Committee, with the presentation of the winners of the Annual Science Talent Search. Dr. Yohe reported that 152 high-school science teachers requested 1,138 examination papers for students to use in the 17th Annual Westinghouse Science Talent Search. Of these, 163 were completed and submitted to the Science Clubs of America for judging. Illinois students won 4 of the 40 Washington trip awards and 16 of the 260 National Honorable Mention citations. The Science Talent Search Committee selected 15 additional State Honorable Mention awards from the remaining 143 entries.

Dr. N. R. Brewer, representing the Illinois Society for Medical Research, presented the awards in the essay contest sponsored jointly by that society and the Academy.

The annual public lecture was given by Dr. Harlow B. Mills, Chief, Illinois Natural History Survey. Dr. Mill's lecture, "The First Hundred Years", dwelt upon the history of the Illinois Natural History Survey which is this year celebrating its centennial. Following the lecture, members of the Academy attended an open house in the Natural Resources Building for an inspection of the facilities of the Natural History Survey.

Council Meetings

The Council held four meetings during the year.

The first was held in the Student Union Building, Illinois State Normal University, Normal, Illinois, on Saturday, May 4, 1957, with Dr. Wayne Wantland presiding. Dr. Gross reported that 910 exhibits were presented in McCormick Gymnasium and 605 persons attended the Junior Academy banquet. Because of the increase in number of ex-

hibits, the Council felt that standards of judging should be raised at the district level to reduce the number of entries at the state level; the large number of entries makes it difficult for the Academy to find a place for its annual meetings.

The Council appointed Dr. Harvey I. Fisher as Technical Editor and James S. Ayars as Publicity Adviser for the next year. The Council also elected Dr. G. E. Ekblaw and Dr. John C. McGregor to the Committee on Publications.

The Council empowered the President and the Secretary to obtain a site for the 51st annual meeting in May, 1958, and to appoint a Second Vice-President after the 1958 meeting place was designated.

Dr. James Neckers submitted the proposed budget for 1957-1958 which was approved after several modifications.

Dr. L. J. Thomas presented a proposal for the writing of a "History of Science in Illinois" for the AAAS. The President was empowered by the Council to accept an offer of the Illinois Historical Survey to work on this and to appoint additional persons to give information.

By mail vote on May 29, 1958, the Council elected Dr. W. A. Lindbeck, Northern Illinois University, the Junior Academy Chairman-elect.

The second meeting of the Council was held in the Coral Room of the Hotel St. Nicholas, Springfield, Illinois, on Saturday, November 16, 1957, with 19 persons attending. Dr. Wantland presided.

Dr. H. B. Mills reported that the 51st annual meeting would be held at the University of Illinois, Urbana, on May 8, 9 and 10, 1958. He also reported that the President of the Academy had appointed Dr. Paul Silva as Second Vice-President in charge of local arrangements.

Dr. Thorne Deuel discussed printing costs of the *Transactions* and the necessity to reduce the number of pages to keep Volume 50 within the allotted budget. The Council asked Dr. Deuel to ascertain if there are any ways by which the Academy could add funds to assist in the publication of the *Transactions*.

The Secretary read a letter from Dr. H. J. Fuller in which he asked to be relieved of duties as Collegiate Section Coordinator because of ill health. The Council accepted this resignation with regrets and elected Dr. Norman D. Levine, University of Illinois, to fill this vacancy.

Miss Elnore Stoldt, reporting for the Junior Academy Advisory and Scholarship Committee, presented a proposal for the establishment of a permanent central meeting place for the exhibits of the state meetings of the Junior Academy so that the state meetings could be held at the same place each year. Dr. Mills suggested that these proposals be put into writing and circularized in the Council so that the Council could think about them and act later.

Dr. Percival Robertson made a report for the State Museum Building Committee. The Council approved the proposal that the committee be permitted to circularize any or all members of the Academy to enlist their support in the endeavor to get a new building for the Museum.

Dr. R. L. Carmin, Co-chairman of the Membership Committee, asked to be relieved of this duty as he planned to be out-of-the-state for more than six months. The Council granted this request and appointed Mr. John Harrison, State Geological Survey, as Co-chairman.

Dr. Harlow B. Mills then reported upon the establishment of the Frank H. Reed Memorial Fund which was set up by the Council on October 27, 1957, by a mail vote. The Council voted the establishment of a Frank H. Reed Memorial Award to be presented to an outstanding Illinois high-school student according to conditions determined by the Junior Academy Executive Group.

The Council appointed Dr. W. B. Welch as delegate to the A.A.A.S and Miss Elnore Stoldt delegate to the Academy Conference.

Dr. George Ekblaw called to the Council's attention the fact that 1958 is the Centennial of the Illinois Natural History Survey as a scientific organization in the State of Illinois. He suggested that the Academy should recognize this anniversary and that the evening public lecture be presented by Dr. Mills, Chief of the Survey. The Council approved this suggestion.

The third meeting of the Council was held in the Faculty Lounge, Illini Union, University of Illinois, Urbana, Illinois, on Saturday, February 15, 1958, with 17 persons in attendance and Dr. Wantland presiding.

Dr. Chalmer Gross introduced Dr. Lawrence C. Bliss, Department of Botany, University of Illinois, who had consented to serve as Exhibits Chairman of the Junior Academy for 1958. Dr. Gross informed the Council that the program of the Junior Academy was complete for the 1958 meeting.

Dr. Paul Silva reported on the organization for the 51st Annual Meeting and the arrangements made for the Senior and the Junior Academy.

Dr. Harvey I. Fisher outlined the work that has been done on the current *Transactions* and told the Council that it was necessary either to reduce the number of pages to be published or to obtain more funds. To facilitate the publication of Volume 50 of the *Transactions*, the Council approved a motion made by Dr. Mills, seconded by Dr. Levine, that the budget be so revised that, out of surplus funds of the Academy, an amount be allotted beyond the $1,000.00 previously allotted which would allow for the publication of all manuscripts that had been accepted and edited, the amount being approximately $600.00.

Miss Stoldt opened for discussion and Council action the problem of a permanent meeting site for the Annual Meetings of the Junior Academy. She received proposals from Springfield and from the University of Illinois. The Secretary was asked to read the invitation from Dr. David D. Henry, President of the University of Illinois and the accompanying letter from Dr. Royden Dangerfield in which the facilities of the University were outlined.

To get this on the floor for discussion, Dr. Mills moved that the Illinois State Academy of Science accept the invitation of President Henry to have the Junior Academy meet regularly on the University of Illinois campus, Urbana, in the spring of the year. Mr. Bamber seconded the motion. In the discussion it was brought out that the University had made definite proposals and the Academy knew what obligations they and the University had in this matter. After further discussion the motion carried unanimously.

Dr. Wayne Wantland appointed Dr. Gross, Dr. Thomas, and Dr. Silva to act as liaison between the Academy and the University.

Dr. Walter Welch who served as delegate to the A.A.A.S. gave an interesting report on the A.A.A.S. meetings in Indianapolis. Miss Stoldt reported on the meeting of the Academy Conference.

Dr. Norman Levine made the motion, seconded by Mr. Bamber, that the President appoint and instruct a planning committee to look into the activities and plans of the Senior Academy and Collegiate Section with the idea of the betterment of the Academy. The motion carried.

The fourth meeting of the Council was held Thursday, May 8, 1958, at the Town and Country Steak House, Urbana, Illinois, with 30 attending the meeting at which Dr. Wantland presided. Dr. Silva reported on the local arrangements for the 51st Annual Meeting. The officers, committee chairmen and section chairmen gave reports that are included in the report of the Annual Business Meeting which follows.

Annual Business Meeting

The business meeting of the 51st annual meetings of the Illinois State Academy of Science was held May 9, 1958, in the Auditorium, University of Illinois, Urbana, Illinois, at 5:00 p.m., C.D.T, with President Wayne Wantland presiding.

The report of the Secretary, which follows, was seconded by Mr. Bamber and accepted.

The minutes of the 50th Annual Meeting, held in Capen Auditorium, Illinois State Normal University, Normal, Illinois, were published in Volume 50 of the *Transactions*. Mimeographed copies have been prepared and distributed in this meeting. The minutes include the actions of the Council and the reports of the standing and special committees.

Activities of the Academy have been summarized in the President's Annual Letter which, with the program of the 51st Annual Meeting was mailed to each member on the Secretary's mailing list as of April 1, 1958.

Mr. President, I move the acceptance of the report of the 50th Annual Meeting as mimeographed and also the summary of the year's activities as indicated in the President's Annual Letter.

Dr. Walter Welch presented the Treasurer's Report which follows. He moved the acceptance of the report, Dr. Levine seconded and the motion carried.

Dr. Chalmer Gross, Chairman of the Junior Academy, filed his report previously with the Secretary. Of special interest in this report was the increase in registered science clubs in the past year. an increase from 184 to 231.

Dr. Harvey I. Fisher, Technical Editor, reported on the present status of Volume 50 of the *Transactions*. Mr. James S. Ayars, Publicity Adviser, reported on the press coverage of Academy activities in the past year.

Reports of Standing Committees

Conservation.—Dr. Willard Klimstra presented the report for the committee;

TREASURER'S REPORT, 1957-58

BALANCE, May 1, 1957		$ 6,920.81
RECEIPTS		
Dues		
Annual		
Regular	$ 2,940.50	
Sustaining	1,015.00	
Life	50.00	
Registration at Normal	139.50	
Refunds	42.50	
Interest		
U. S. bonds	72.60	
Savings	140.00	
Research grants	365.50	
Void checks	475.00	
Frank H. Reed Memorial Fund	400.00	
	$ 5,640.60	$ 12,561.41
National Science Foundation		
Undergraduate Research Conference	$ 4,082.19	
TOTAL, balance and receipts		$ 16,643.60
EXPENDITURES		
Council	$ 243.11	
Secretary's office	823.46	
Treasurer's office	409.58	
Editor's office	137.27	
Miscellaneous	24.40	
Research grants	485.00	
Membership committee	290.89	
Honoraria	350.00	
Junior Academy		
General	2,329.32	
Science talent search	365.61	
Frank H. Reed Memorial Fund	400.00	
Collegiate section	10.61	
National Science Foundation		
Undergraduate Research Conference	531.43	
TOTAL expenditures		$ 6,400.68
CASH ON HAND, April 30, 1958	$ 6,160.73	
Outstanding checks	202.16	
TOTAL, Carbondale National Bank, April 30, 1958		$ 6,362.89
BALANCE, National Science Foundation		$ 3,550.76
RESERVE FUND		
State Savings and Loan Association, East St. Louis, Illinois	$ 4,000.00	
U. S. bonds	1,800.00	
		$ 5,800.00
PERMANENT FUND		
Life memberships in		
U. S. bonds	$ 1,200.00	
Cash in Carbondale National Bank	500.00	
		$ 1,700.00
FRANK H. REED MEMORIAL FUND	$ 400.00	
Interest on shares, East St. Louis	1.17	
		$ 401.17
Total funds		$ 7,901.17

much of this report appears with the resolutions enumerated below.

Budget.—Dr. James Neckers stated that the Committee had prepared a budget for 1958-1959 and would present this at the first meeting of the Council on Saturday, May 10.

Membership.—Mr. Gideon Boewe summarized the activities of the Membership Committee. He then moved that persons who have applied for membership during the past year and who have met the qualifications be elected to membership. Dr. Welch seconded the motion which carried.

Research Grants.—Dr. H. F. Thut informed the members that only one request, for $100.00, had been received by this committee.

Science Talent.—Dr. G. R. Yohe gave the report and this has been summarized above.

State Museum Building.—Dr. Percival Robertson filed his report earlier with the Secretary. This report included copies of a letter and informative material which that commmittee had sent out to all members of the Academy.

REPORTS OF SPECIAL COMMITTEES

Auditing.—The report of the Auditing Committee was read by the Secretary who moved acceptance of the report which follows. Mr. Bamber seconded the motion which carried.

To whom it may concern:

This is to certify that the Auditing Committee has examined the financial accounts of the Treasurer of the Illinois State Academy of Science and has found them to be correct and to check with the statement of balance by the Carbondale National Bank. This audit was made as of May 5, 1958.

(Signed) Clyde M. Brown
Willard D. Klimstra
Charles L. Foote, *Chairman*
Auditing Committee

Resolutions.—Dr. Paul Shaffer presented the report of the committee and the following ten resolutions were adopted by the Academy.

1. Appreciation to Host. *Whereas* many persons in the Champaign-Urbana area have been of great service to the Illinois State Academy of Science for the several ways in which they have made the necessary arrangements for the fifty-first annual meeting, therefore,
Be it resolved that the Academy express its gratitude to all who have participated in any way in arranging this annual meeting, particularly, President David D. Henry, Provost Gordon N. Ray, Dean Royden Dangerfield, Dean Joseph R. Smiley, and the heads of the various science departments of the University of Illinois, who invited the Senior Academy to hold its annual meeting on the campus and arranged for the University to become the permanent annual meeting place for the Junior Academy,
The University Extension Service for its help in the Academy arrangements and the Illini Union and the Housing Division for their outstanding contributions toward feeding and housing the more than 1500 members of the Junior Academy present,
The State Geological and Natural History surveys for their continued support of the field trip program and their many other aids,
The University Physical Plant Department for its aid in setting up and lighting the scientific exhibit area for the Junior Academy and for their other help.
Be it further resolved that the secretary be authorized to send copies of this resolution to those specifically named and to the chiefs of the surveys, heads of the science departments, and to the director of the physical plant department.
2. Illinois State Museum. *Whereas* the Illinois State Museum has compiled a record of outstanding service in the field of scientific education during the past 81 years, and has served an increasing number of individuals each year so that in 1957 more than 1,300,000 were served, and
Whereas the potentialities for future service in this age when the dissemination of scientific information is so vital, is limited by the facilities available,
Be it resolved that the Illinois State Academy of Science, numbering about 1200 scientists located mainly in Illinois, respectfully requests, the Governor and the Budgetary Commission of the Illinois Legislature to consider the needs for adequate space for the museum and its very capable staff.
Be it further resolved that the Secretary of the Academy send a copy of this resolution to the Honorable

William G. Stratton, Governor, and the Chairman of the Budgetary Commission.

3. Illinois Natural History Survey. *Whereas*, the Illinois Natural History Survey is celebrating its 100th birthday, and
Whereas, during this century, under the able guidance of its directors, namely Dr. Stephen A. Forbes, Dr. Theodore H. Frison, Dr. Leo R. Tehon, and Dr. Harlow B. Mills, the Survey has been strongly active as a guardian of the natural resources of Illinois and pioneered in wise utilization of these resources,
Be it resolved that the Illinois State Academy of Science recognize the contributions of this outstanding agency and its leaders, and that the Secretary of the Academy be instructed to transmit a copy of this resolution to Dr. Harlow B. Mills, Chief of the Survey.
4. Toll Road Vegetation. *Whereas*, toll road systems throughout the State of Illinois are making extensive utilization of land area, and resulting right-of-ways will require extensive development and management,
Be it resolved that the Illinois State Academy of Science strongly encourage the Illinois Toll Road Commission to utilize native vegetation in the development of these right-of-ways to assist in maintaining a part of our natural biota which are an important aspect of the heritage and culture of the State of Illinois.
Be it further resolved that the Secretary of the Academy be instructed to send a copy of this resolution to the Commission and that the Council be requested to arrange a meeting of an appropriate representative of the Academy with the Commission to discuss the intent of this resolution.
5. Department of Conservation. *Whereas*, the Illinois Department of Conservation has progressively recognized its position as the responsible administrator of policies which are in the best interest of our natural resources as evidenced by: the delayed cotton-tail rabbit season so as to avoid infection of human beings with tularemia; the recognition of the need for, and successful operation of the white-tailed deer harvest; elimination of field trials on the Green River Refuge to aid in protection of the prairie chicken; instigation of a technical bulletin series for publication of wildlife research; support for, and perseverance, to obtain passage of a model hawk and owl law; and recognition of the need for the reclassification and salary readjustment of departmental personnel,
Be it resolved that the Illinois Academy of Science strongly commend the Illinois Department of Conservation for these favorable actions and request that it further emphasize preservation of prairie chicken in the Green River Refuge by removing this area from use as a public shooting area.
Be it further resolved that the Academy encourage the Department of Conservation to provide greater recognition of trained and professional researchers through increased salaries and job ratings.
Be it further resolved that the Secretary of the Academy be instructed to send a copy of this resolution to Mr. Glen Palmer, Director, Illinois Department of Conservation.
6. Insecticides and Herbicides. *Whereas*, problems are evident regarding effects of almost unrestricted use of insecticides and herbicides on man and his environment, and
Whereas, these substances likewise have a recognized usefulness,
Be it resolved that individual members of the Illinois Academy of Science strongly encourage various state, federal, and private agencies to support and promote all efforts to provide a better understanding of the total effects that insecticides and herbicides have upon man and his environment.
7. Exotic Plants and Animals. *Whereas*, the introduction of exotic plants and animals has often yielded undesirable results, and unless introductions are carefully tested and evaluated the potential for undesirable results is ever present,
Be it resolved that the Illinois Academy of Science request the Illinois Departments of Conservation and Agriculture to exercise fully their respective powers to control introduction of all exotics into the State of Illinois.
Be it further resolved that the Council of the Academy be instructed to carry out to the extent of its powers the intent of this resolution.
8. Training in Conservation. *Whereas*,

there continues to be a great need for recognition of the importance of natural resources not only in Illinois, but in all the United States and the remainder of the world, and

Whereas, such an understanding is best obtained through our primary and secondary school systems, and

Whereas, many teachers in these public schools are trained at various colleges and universities of Illinois, and

Whereas, as a result of the new scientific age greater emphasis may be put on physical sciences with little recognition of the importance of the biological and even less of wise utilization of resources,

Be it resolved that the members of the Illinois State Academy of Science strongly encourage, through their representation in the Illinois Assembly, the establishment of a requirement similar to that of Wisconsin for conservation training in the requirements for qualification as a primary or secondary school teacher.

9. Non-Resident Collecting. *Whereas*, the Fish, Game and Forestry Codes of the State of Illinois provide protection for only a limited portion of our fauna, and

Whereas, a number of species are rare and are endangered by promiscuous collecting,

Be it resolved that the Illinois State Academy of Science request that the Illinois Department of Conservation encourage passage of a legislative measure that will require all non-residents to obtain permission for the collecting of vertebrate animals within the boundaries of the State of Illinois and that such permission will require a statement as to the group or groups of vertebrates to be collected, sites for collecting, and that a final report of such collecting be filed with the Illinois Department of Conservation and the Illinois Natural History Survey, stating kind, number, and locality of all vertebrate animals obtained.

Be it further resolved that the Secretary of the Academy be instructed to send a copy of this resolution to Mr. Glen Palmer, Director, Illinois Department of Conservation, and that the council be requested to keep check on the progress of action directed toward the completion of the objectives of this resolution.

10. Necrology. *Whereas* during the past year the Academy lost by death, the members listed below:

Chester Wallace Bennett, Jan. 15, 1958
Mary A. Bennett, August 12, 1957
Frank Walbridge DeWolf, Sept. 16, 1957
Herbert E. Hillebrecht, May 27, 1957
Frederick Kettner, March 1957
Vasili I. Komarewsky, June 21, 1957
Ira E. Neifert, March 28, 1958
Lucille H. Snow, 1957
Claude U. Stone, Nov. 14, 1957

Be it resolved that the Academy express its grief over their passing by rising for a moment of silence.

(Signed)
Harold Kaplan,
Walter Scruggs,
Howard W. Gould,
Paul R. Shaffer, *Chairman*.

Dr. Shaffer presented a late resolution to the Secretary. This resolution from the Physics Section was to be further studied by the Council and the Teacher Training Committee.

Nominating.—This committee consisted of Dr. W. W. Grimm, *Chairman*, Mr. Lyle Bamber, Dr. C. Leplie Kanatzar, Dr. Hiram F. Thut, Dr. James W. Neckers, and Dr. Harold R. Wanless. Dr. Grimm first presented the names of the nominees for officers and members of the Council. Dr. Wantland asked for further nominations from the floor. There being none, Dr. Grimm moved the President cast a unanimous ballot for those nominated and declare them elected. Dr. Shaffer seconded the motion which carried. Dr. Grimm then read the nominations for Committee Members and, after no further nominations were made from the floor, moved these be elected. Dr. Levine seconded the motion which carried. This list of officers and committee members will be published in the *Transactions*.

Planning.—Dr. Levine outlined the changes proposed by this committee. The Planning Committee made the following recommendations:

1). That the Senior Academy annual meeting be held two weeks before the Junior Academy meeting, or, if Easter falls on that week-end, that it be held three weeks before the Junior Academy meeting.

2). That, to the end that membership on the Academy's committees be as

broad as possible, no individual should be a member of more than two standing committees, that there be reasonable rotation of membership within committees, and that the Secretary send out a letter to all members between the first and second Council meetings following the next annual meeting, listing the Academy's committees and asking the members to tell him which committees they would be willing to serve and work on. The returns would then be used to help make committee assignments.

3). That the Committee on Living Memorials be eliminated and that the State Museum Building Committee be removed from the list of standing committees as soon as it has finished its current mission and be made an *ad hoc* committee to be appointed by the Council as needed.

4). That a one-day Refresher Course be held for high-school, junior-college and other teachers at the 1959 meeting of the Academy. This course would cover recent advances in a field to be selected by the Council. The Friday morning general lecture could be coordinated with it. The course should be advertised not only to members of the Academy but also through high-school principals, school boards, etc.

5). That the *Transactions* of the Academy be enlarged and issued quarterly, that each issue be composed of the following three sections: (a) a Senior Academy section which would include papers from the Collegiate Section competing on an equal basis with those of the other sections; (b) a Junior Academy section, and (c) News and Notes. The committee recommends further that the *Transactions* have an Editor and a Board of Editors composed of Associate Editors for the Junior Academy section, for News and Notes, and for the technical sections as needed. It recommends further that papers be accepted for publication in the *Transactions* through the year rather than only at the time of the annual meeting.

6). That the Academy request the State Museum to request the General Assembly to appropriate approximately $10,000 a year to it for publication of the *Transactions*.

7). That, in order to implement the above recommendations, the following changes in the Academy's By-Laws be adopted at the 1958 meeting of the Academy: (The amended By-Laws are published below).

Planning Commitee
Robert A. Evers, *ex officio*,
Harvey I. Fisher,
John C. Frye,
Wilbur W. Grimm,
Francis J. Kruidenier,
Charles D. Proctor,
Paul C. Silva,
Lyell J. Thomas,
Norman D. Levine, *Chairman*.

Dr. Levine moved the acceptance of their recommendations and changes in the By-Laws. Dr. Ekblaw seconded the motion which carried.

Upon a motion by Dr. Welch, seconded by Dr. Grimm the meeting adjourned at 5:55 p.m., C.D.T.

BY-LAWS OF THE ILLINOIS STATE ACADEMY OF SCIENCE

(As revised in the 51st Annual Meeting, May 9, 1958)

I. Order of Business

1. The business meetings of the Academy and the meetings of the Council shall be conducted in accordance with Robert's Rules of Order.

2. Fifteen members shall constitute a quorum of the Academy and six councillors shall constitute a quorum of the Council.

II. Committees and Delegates

1. The standing committees of the Academy shall be Affiliations, Animal Experimentation in Research, Budget, Conservation, Archaeological and Historical Sites, Junior Academy Advisory and Scholarship, Legislation and Finance, Local Conventions, Membership, Research Grants, Science Talent, Sustaining Memberships, State Museum Building, and Teacher Training. Any of these committees may be abolished and additional ones may be established upon recommendation of the Council at any annual meeting of the Academy.

2. The chairmen and members of the standing committees shall be elected by the members of the Academy at its annual meeting. Interim vacancies on the committees shall be filled by the Council, who shall have authority also to elect additional members.

3. The Local Conventions Committee shall consist of the last three available Second Vice-Presidents, the Secretary of the Academy *ex-officio*, and a representative of the Junior Academy.

4. There shall also be committees on Audit, Nominations, and Resolutions of which the members shall be appointed by the President not later than the February Council meeting.

5. The duties of the committees shall be as defined by the Council, except as hereafter provided.

6. The Budget Committee shall submit at the last Council meeting for its consideration and for review at the annual meeting of the Academy a budget of anticipated income and recommended expenditures for the following year. The budget shall be approved by the succeeding Council at its first meeting.

7. The Junior Academy Advisory and Scholarship Committee shall supervise the management of the affairs of the Junior Academy in accordance with policies and principles determined by the Council.

8. The Local Conventions Committee shall prepare and maintain up-to-date a "hand book" for the guidance of Second Vice-Presidents in discharging their duties as Chairmen of Local Arrangements and shall further advise such officers when requested.

9. The membership of the Audit, Nominations, and Resolutions committees shall be announced to the members of the Academy by the President or the Secretary not less than 30 days prior to the annual meeting.

10. The Nominations Committee shall present at the annual business meeting of the Academy a list of candidates for all offices and committees which shall be filled by election by members of the Academy.

11. The Resolutions Committee shall present at the annual business meeting of the Academy all resolutions for consideration by the members of the Academy, with recommendations for or against approval. Members of the Academy who wish to sponsor resolutions shall submit them to the Resolutions Committee for consideration not less than 24 hours and preferably longer before the annual meeting. No resolution not submitted to the Committee may be presented at the meeting of the Academy. The Committee shall draft any appropriate resolutions as directed by the officers of the Academy or Council, may redraft any resolution submitted by any member or members to place it in more acceptable form, and may draft resolutions to incorporate suggestions offered by members of the Academy.

12. One or more delegates to the American Association for the Advancement of Science or to any other organization with which the Academy is affiliated, when such delegates are required, shall be elected each year by the Council.

III. Technical Sections

1. Technical papers presented at the annual meeting of the Academy will be distributed among Sections representing various fields of science as follows: Aquatic Biology; Archeology and An-

thropology; Botany; Chemistry; Geography; Geology; Physics; Science Education, Psychology, and Social Science; Zoology; and Collegiate.

2. Any of these sections may be abolished, divided, or combined by the Council as seems desirable, and other sections may be established by the Council upon request of ten active members.

3. Members of the Academy shall indicate in which section or sections they are particularly interested.

4. The members present at any section meeting during the annual meeting of the Academy shall constitute a quorum of the section. They shall elect a chairman for the ensuing year, who shall be responsible for assembling a program for the section for the next meeting. In the event that an elected chairman can not serve, a substitute shall be elected by the Council.

5. The Coordinator of the Collegiate Section shall cooperate with its elected officers in conducting its affairs, subject to the advice and approval of the Council.

6. No paper shall be entitled to a place on the Section programs unless the manuscript or an abstract of the same shall have been previously delivered to the Secretary in accordance with instructions. No paper shall be presented at any Section meeting by any person other than the author, except with approval of a majority of the members present at such meeting. No paper shall be accepted for publication unless the author or a co-author is a member of the Academy or an approved applicant for membership or unless it has been presented at the invitation of or with the approval of the Council, nor shall any paper published wholly or in large part elsewhere be acceptable for publication.

IV. Publications

1. The publications of the Academy shall be under the supervision of a Committee on Publications, which shall consist of an Editor and a Board of Editors.

2. The Editor shall be appointed annually by the Council at its first meeting. He shall be chairman of the Committee on Publications and Technical Editor.

3. The Board of Editors shall consist of eight Associate Editors, of which one shall be for the Junior Academy, one shall be for News and Notes, and six shall represent the various areas of science. The Associate Editors shall be appointed annually by the Council at its first meeting.

4. Sometime between May 1 and September 1 of even-numbered years the Editor and/or the members of the Board of Editors shall confer with the Director of the Illinois State Museum concerning the amount of appropriations that should be requested for publication of the *Transactions* during the next State Biennium.

V. Suspension or Amendment of By-Laws

1. These by-laws may be suspended or amended at any annual meeting of the Academy by a majority vote of the members present.

OFFICERS, COMMITTEES, DELEGATES, AND SECTION CHAIRMEN, 1958-1959

Officers

PRESIDENT: Harlow B. Mills, State Natural History Survey, Urbana.
FIRST VICE-PRESIDENT: C. Leplie Kanatzar, MacMurray College, Jacksonville.
SECOND VICE-PRESIDENT: Leslie R. Hedrick, Illinois Institute of Technology, Chicago.
SECRETARY: R. A. Evers, State Natural History Survey, Urbana.
TREASURER: Walter B. Welch, Southern Illinois University, Carbondale.
LIBRARIAN: Thorne Deuel, State Museum, Springfield.

The Council

The Council consists of the above listed six officers and the following persons:

GENERAL CHAIRMAN: JUNIOR ACADEMY OF SCIENCE: Wendell A. Lindbeck, Northern Illinois University, DeKalb.

COORDINATOR OF THE COLLEGIATE SECTION: Norman D. Levine, University of Illinois, Urbana.

COUNCILORS: Wayne W. Wantland, Illinois Wesleyan University, Bloomington.
Lyle E. Bamber, University of Illinois, Urbana.
Joan Hunter, Edwardsville High School, Edwardsville.

Delegates

DELEGATES TO THE A.A.A.S.:
Walter B. Welch, Southern Illinois University, Carbondale.
Elnore Stoldt, Jacksonville High School, Jacksonville.

Committees

AFFILIATIONS:
George E. Ekblaw, *Chairman*, State Geological Survey, Urbana.
Thorne Deuel, Illinois State Museum, Springfield.
L. H. Tiffany, Northwestern University, Evanston.
Elbert H. Hadley, Southern Illinois University, Carbondale.

ANIMAL EXPERIMENTATION IN RESEARCH:
Harold Kaplan, *Chairman*, Southern Illinois University, Carbondale.
Garland T. Riegel, Eastern Illinois University, Charleston.
Donald T. Ries, Illinois State Normal University, Normal.
F. R. Steggerda, University of Illinois, Urbana.

BUDGET:
J. W. Neckers, *Chairman*, Southern Illinois University, Carbondale.
W. W. Wantland, Illinois Wesleyan University, Bloomington.
Lyle E. Bamber, University of Illinois, Urbana.

CONSERVATION:
Willard Klimstra, *Chairman*, Southern Illinois University, Carbondale.
Harlow B. Mills, State Natural History Survey, Urbana.
John C. Frye, State Geological Survey, Urbana.
J. Nelson Spaeth, University of Illinois, Urbana.
G. Neville Jones, University of Illinois, Urbana.
Henry Sather, Western Illinois University, Macomb.
S. Charles Kendeigh, University of Illinois, Urbana.
Stanley A. Changnon, Jr., State Water Survey, Urbana.

CONSERVATION OF ARCHAEOLOGICAL AND HISTORICAL SITES:

Thorne Deuel, *Chairman*, Illinois State Museum, Springfield.
John C. McGregor, University of Illinois, Urbana.
Fay-Cooper Cole, University of Chicago, Chicago.
C. C. Burford, 907 S. Orchard, Urbana.
William H. Farley, Box 433, Harrisburg.
Sol Tax, 1126 East 59th St., Chicago.

JUNIOR ACADEMY ADVISORY AND SCHOLARSHIP:

Lyell J. Thomas, *Chairman*, University of Illinois, Urbana.
Elnore Stoldt, Jacksonville High School, Jacksonville.
Percival Robertson, The Principia, Elsah.
Chalmer A. Gross, Southern Illinois University, Carbondale.
Albert Willis, 11 S. LaSalle St., Chicago.
Lewis Hollmeyer, Office of State Superintendent of Public Instruction, Springfield.
M. G. Moore, Office of State Superintendent of Public Instruction, Springfield.

LEGISLATION AND FINANCE:

Percival Robertson, *Chairman*, The Principia, Elsah.
Morris M. Leighton, State Geological Survey, Urbana.
Loren P. Woods, Chicago Museum of Natural History, Chicago.

LOCAL CONVENTIONS:

Paul C. Silva, *Chairman*, University of Illinois, Urbana.
C. W. Hudelson, Illinois State Normal University, Normal.
Glen S. Winterringer, State Museum, Springfield.
W. A. Lindbeck, Northern Illinois University, DeKalb.
R. A. Evers, *ex-officio*, State Natural History Survey, Urbana.

MEMBERSHIP:

G. H. Boewe, *Chairman*, State Natural History Survey, Urbana.
Robert L. Carmin, *Co-Chairman*, University of Illinois, Urbana.
John Harrison, *Co-chairman*, State Geological Survey, Urbana.
Donald C. Boardman, Wheaton College, Wheaton.
Robert A. Bullington, Northern Illinois University, DeKalb.
Wesley Calef, University of Chicago, Chicago.
Esther Griffith, Illinois State Normal University, Normal.
W. N. Stewart, University of Illinois, Urbana.
A. F. Silkett, University of Illinois, Navy Pier, Chicago.
C. Leplie Kanatzar, MacMurray College, Jacksonville.
Ben T. Shawver, Monmouth College, Monmouth.
Karl G. Larson, Augustana College, Rock Island.
Herbert Priestly, Knox College, Galesburg.
Irvin L. Sparks, Eastern Illinois University, Charleston.
Charles D. Proctor, Loyola University, Chicago.

RESEARCH GRANTS:

Paul R. Shaffer, *Chairman*, University of Illinois, Urbana.
Charles L. Foote, Southern Illinois University, Carbondale.
H. F. Thut, Eastern Illinois University, Charleston.

TEACHER TRAINING:

Harry J. Fuller, *Chairman*, University of Illinois, Urbana.
Joan Hunter, *Co-chairman*, Edwardsville High School, Edwardsville.
E. R. Erickson, Augustana College, Rock Island.
A. Frances Johnson, Rockford College, Rockford.
Reece A. Jones, Western Illinois University, Macomb.
Glenn Q. Lefler, Eastern Illinois University, Charleston.

SCIENCE TALENT:

G. R. Yohe, *Chairman*, State Geological Survey, Urbana.
Lawrence R. Heckard, University of Illinois, Urbana.
Edward J. Scott, University of Illinois, Urbana.
E. F. Potthoff, University of Illinois, Urbana.
C. S. Robinson, University of Illinois, Urbana.
Ralph Yeatter, State Natural History Survey, Urbana.
James S. Ayars, State Natural History Survey, Urbana.

SUSTAINING MEMBERSHIPS:

C. Leplie Kanatzar, *Chairman*, MacMurray College, Jacksonville.
Paul D. Voth, University of Chicago, Chicago.
Robert A. Berntsen, Augustana College, Rock Island.
Wilbur W. Grimm, Bradley University, Feoria.
Robert A. Bullington, Northern Illinois University, DeKalb.
Milton Thompson, Illinois State Museum, Springfield.
Ralph P. Frazier, Monmouth College, Monmouth.

STATE MUSEUM BUILDING:

Percival Robertson, *Chairman*, The Principia, Elsah.
Ernest L. Stover, Eastern Illinois University, Charleston.
Frederick C. Holtz, Sangamo Electric Co., Springfield.

Technical Personnel

EDITOR: Harvey I. Fisher, Southern Illinois University, Carbondale.

PUBLICITY ADVISER: James S. Ayars, State Natural History Survey, Urbana.

Section Chairmen

AQUATIC BIOLOGY: Homer Buck, State Natural History Survey, Dundee

ARCHAEOLOGY AND ANTHROPOLOGY: Howard D. Winters, Southern Illinois University, Carbondale.

BOTANY: Kenneth Damann, Eastern Illinois University, Charleston.

CHEMISTRY: J. V. Karabinos, Blockson Chemical Co., Joliet.

GEOGRAPHY: Dalias A. Price, Eastern Illinois University, Charleston.

GEOLOGY: Paul R. Shaffer, University of Illinois, Urbana.

PHYSICS: Clarence R. Smith, Aurora College, Aurora.

SCIENCE EDUCATION, PSYCHOLOGY AND SOCIAL SCIENCE: Lawrence Hubbell, 7029 N. Hiawatha, Chicago.

ZOOLOGY: Donald F. Hoffmeister, University of Illinois, Urbana.

COLLEGIATE: Miss Marlene Stepaniak, College of St. Francis, Joliet.

PREPARATION OF MANUSCRIPTS FOR THE TRANSACTIONS

For publication in the *Transactions*, articles must present significant material that has not been published elsewhere. Review articles are excepted from this provision, as are brief quotations necessary to consider new material or varying concepts. All manuscripts must be typewritten, double spaced, with at least one-inch margins. The original copy, not the carbon copy, is to be submitted.

Titles should be brief and informative. The address or institutional connection of the author appears just below the author's name. Subtitles or center headings should be used; ordinarily one uses subtitles such as *Introduction*, *Acknowledgments*, *Materials*, *Methods*, *Results*, *Discussion*, *Summary*, and *Literature Cited*. All papers should have a summary.

No footnotes are to be used.

The section entitled *Literature Cited* must include all references mentioned in text. It is not to include any other titles. No references to the literature are to be placed in footnotes. Citations under *Literature Cited* are as shown below:

Doe, John H. 1951. The life cycle of a land snail. Conchol., 26(3): 21-32, 2 tables, 3 figs.

Doe, John H. 1951. Mineralogy of Lower Tertiary deposits. New York, McGraw-Hill Book Co., iv + 396 pp.

Quoted passages, titles, and citations must be checked and rechecked for accuracy. Citations to particular pages in text are Doe (1908:21-36) or (Doe, 1908:21-36); general citation in text is Doe (1908) or (Doe, 1908).

Tabular information should be kept at a minimum. Tables should not be more than one page in length. Do not duplicate tabular data in text. Headings for tables and columns should be brief. Reduce to the barest essentials, or preferably omit, explanatory notes on tables. Each table and its heading should be on a single page; do not place any table on the same page with text.

Photographs should be hard, glossy prints of good contrast. Graphs, maps and other figures reproduce best when prepared for at least one-half reduction; lettering, numerals, etc. on all figures in a manuscript should be worked out to proper size for such reduction. Line widths, letter size etc. should be uniform from figure to figure within a published paper. Figures should be drawn on good quality white paper or on drawing board. Use only India ink. Use a lettering device (Leroy or Wrico) for numerals and words; do not print "free-hand."

Legends for photographs and figures should be brief; type them on a separate sheet of paper. Indicate figure number and your name on back of illustration; do not write with pencil on the backs of photographs.

Authors will receive galley proofs; these should be read carefully and checked against the original manuscript. Reprints may be ordered at the time galley proofs are returned to the Editor:

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